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CONNECTICUT RIVER BASIN
WASHINGTON, NEW HAMPSHIRE

# BUTTERFIELD POND DAM NH 00233

NHWRB NO. 245.01

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

MARCH 1980

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#### DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO ATTENTION OF:

NEDED

7 OCT 1383

Honorable Hugh J. Gallen Governor of the State of New Hampshire State House Concord, New Hampshire 03301

Dear Governor Gallen:

Inclosed is a copy of the Butterfield Pond Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam.

Butterfield Pond Dam has been rated as being in very poor condition. The brief assessment and Section 3 of this report contain a discussion as to the condition of the dam. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, The State of New Hampshire Resource and Economic Development Dept., Division of Parks and Recreation.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely

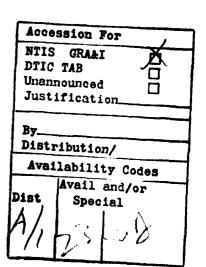
Incl As stated MAX B. SCHEIDER

Colonel, Corps of Engineers

Division Engineer

#### BUTTERFIELD POND DAM NH 00233 NHWRB 245.01

CONNECTICUT RIVER BASIN WASHINGTON, NEW HAMPSHIRE



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



#### NATIONAL DAM INSPECTION PROGRAM PHASE I - INSPECTION REPORT BRIEF ASSESSMENT

Identification No: NH 00233

Name of Dam: Butterfield Pond Dam

Town: Washington

County and State: Sullivan, New Hampshire

Stream: Ashuelot River

Date of Inspection: December 6, 1979

Butterfield Pond Dam is a stone-filled gravity structure about 210 feet in overall length and 12.5 feet high from crest of dam to toe of slope. Located in the center of the dam is the principal overflow section which is 57 feet long and consists of a concrete capped, stone weir with concrete training walls. Near the middle of the overflow section is a 16.2 feet wide by 0.2 feet deep low flow spillway weir cast into the concrete cap. Located at the right training wall of the overflow section is the outlet structure which consists of a reinforced concrete sluice gate structure containing a wood plank sluice gate. Both the left and right embankments consist of unmortared stone. There is no emergency spillway.

The dam impounds Butterfield Pond and adjoining May Pond and the discharge flows through the Ashuelot River in a southwesterly direction approximately 6.0 miles to Ashuelot Pond. The original purpose of the dam is reported to have been to supply power to a mill, but its present use is recreational. The pond is 1.25 miles in length with a surface area of about 126 acres. The maximum storage capacity is about 590 acre feet.

As a result of the visual inspection of this facility, the dam is considered to be in **MERA FOOK** condition. Major concerns are: a sinkhole in the earthfill on the upstream side of the right stone embankment with pond water flowing into the sinkhole; subsidence of the crest and bulging of the downstream slope of the left stone embankment; severely broken and eroded condition of the concrete cap and the downstream concrete facing of the overflow section; and significant leakage and seepage at numerous locations along the downstream face of the dam.

This dam is classified as SMALL in size and a SIGNIFICANT hazard structure in accordance with the recommended guidelines established by the Corps of Engineers. The test flood for this dam therefore, ranges from a 100-year flood to one-half the Probable Maximum Flood (1/2 PMF). Due to the very poor condition of the dam, the 1/2 PMF was selected for this hydrologic analysis. The test flood inflow was estimated to be 7,500 cfs and resulted in a routed test flood outflow equal to 5,430 cfs which would overtop the dam crest by about 5.3 feet. The maximum

spillway discharge capacity with the water level at the dam crest was estimated to be 160 cfs or about 3 percent of the routed test flood outflow. A major breach with the reservoir surface at the dam crest would overtop New Hampshire Route 31, by 2 to 3 feet, where it crosses the channel 350 feet below the dam. This could result in significant damage to the bridge and roadway. Although the potential for loss of life exists if the bridge were to wash out, no loss of life is anticipated.

It is recommended that the owner engage a qualified engineer to: investigate the sinkhole, crest subsidence, erosion channel on the downstream slope, and seepage at the left end of the right stone embankment; investigate the subsidence of the crest, sinkhole in the upstream earthfill, bulging of the downstream slope and seepage at the downstream toe of the left stone embankment; investigate the structural condition of the overflow section and the sluice gate; and do a detailed hydrologic-hydraulic investigation to assess further the potential of overtopping the dam, the adequacy of the spillway to pass the test flood, and the need for and means to increase project discharge capacity. It is also recommended that the owner clear brush and trees from a zone 25 feet wide on each side of the discharge channel between the dam and the highway bridge downstream of the dam.

The recommendations and remedial measures are described in Section 7 and should be addressed by the owner within one year after receipt of this Phase I Inspection Report.

KENNETH STEWART NO. 3531

STEWART NO. 3531

OSTERED HER MINISTRANTING NO. 3531

Kenneth M. Stewart Project Manager N.H.P.E. 3531

S E A Consultants Inc. Rochester, New Hampshire This Phase I Inspection Report on Butterfield Pond Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Chamas antonin

ARAMAST MAHTESIAN, MEMBER Geotechnical Engineering Branch Engineering Division

Carney M. Tazion

CARNEY M. TERZIAN, MEMBER Design Branch Engineering Division

RICHARD DIBUONO, CHAIRMAN

Water Control Branch Engineering Division

APPROVAL RECOMMENDED:

OE B. FRYAR

Chief, Engineering Division

#### PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

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It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and

rarity of such a storm event, finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I investigation does <u>not</u> include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespassing and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

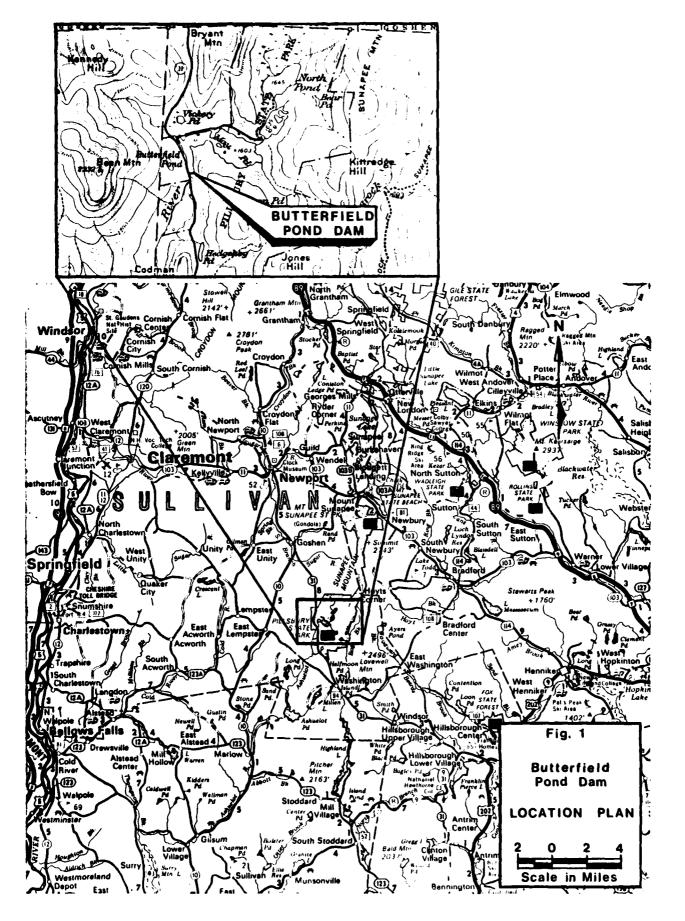
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OVERVIEW PHOTO - BUTTERFIELD POND DAM



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# NATIONAL DAM INSPECTION PROGRAM PHASE I INSPECTION REPORT BUTTERFIELD POND DAM

### SECTION 1 PROJECT INFORMATION

#### 1.1 General

a. <u>Authority.</u> Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. S E A Consultants Inc. has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to S E A Consultants Inc. under a letter of November 5, 1979 from William Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW33-80-C-0008 has been assigned by the Corps of Engineers for this work.

#### b. Purpose

- (1) To perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.
- (2) To encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.
  - (3) To update, verify and complete the National Inventory of Dams.

#### 1.2 Description of Project

- a. Location. The Butterfield Pond Dam is located in the town of Washington, New Hampshire, at the south end of Butterfield Pond, just east of New Hampshire Route 31. The dam impounds water from Butterfield Pond and adjoining May Pond which, after passing over the spillway, flows through the Ashuelot River in a southwesterly direction for approximately 6.0 miles where it discharges into Ashuelot Pond. The dam is shown on U.S.G.S. Quadrangle, Lovewell Mountain, New Hampshire, with coordinates approximately N43°13'33", W72°07'08", Sullivan County, New Hampshire. (See Location Plan)
- b. <u>Description of Dam and Appurtenances</u>. Butterfield Pond Dam is a stone-filled gravity structure with a concrete capped overflow section and a reinforced concrete sluice gate structure. The dam is approximately 210 feet in overall length and 12.5 feet high from crest of dam to toe of slope. Both embankments consist of unmortared stone and have a crest width of approximately

6.0 feet. The left embankment has a downstream slope of unmortared stone which extends from crest of dam to toe of slope at approximately 1.5 feet vertical to 1.0 foot horizontal (1.5:1). The right embankment has a downstream slope of earthfill at approximately 1.0 foot vertical to 2.0 feet horizontal (1:2).

Located in the center of the dam is the principal overflow section which is 57 feet long and consists of a concrete capped, stone weir with concrete training walls. Near the middle of the overflow section is a 16.2 feet wide by 0.2 feet deep low flow spillway weir cast into the concrete cap.

Located at the right training wall of the overflow section is the outlet structure which consists of a reinforced concrete sluice gate structure containing a wood plank sluice gate. All mechanical equipment to operate the sluice gate has been removed and the sluice gate is split, leaking and inoperable. Flow passing through the sluice gate structure discharges into a 12 feet wide stone-lined sluiceway that extends approximately 56 feet to the main channel.

- c. <u>Size Classification</u>. Small (height 12.5 feet; storage 590 acre-feet) based on storage (less than 1,000 acre-feet and greater than or equal to 50 acre-feet) as given in the Recommended Guidelines for Safety Inspection of Dams.
- d. <u>Hazard Classification</u>. Significant Hazard. Failure of the dam could result in damage to a state bridge and highway (NH Route 31), since the capacity of the highway bridge is nearly 2,000 cfs less than the dam failure discharge and the roadway would be overtopped by 2 to 3 feet. There are no dwellings located near the downstream channel until the river discharges into Ashuelot Pond. However, at this point the stage would decrease rapidly to less than a foot and dwellings located on the pond would not be impacted. Although the potential for loss of life would exist if the bridge were to wash out, no loss of life is anticipated.
- e. Ownership. No information regarding the original owner was found, but according to the files of the State of New Hampshire Water Resources Board, the original dam was built to create a pond and provide power for what was called Butterfield Mill. The dam was reconstructed in 1934 by the Civilian Conservation Corp., and at that time was owned by the State of New Hampshire Forestry Reservation. Since that time, the dam has always been owned by an agency of the State of New Hampshire, and is presently owned by Pillsbury State Park; more specifically, the State of New Hampshire Resources and Economic Development Department, Division of Parks and Recreation, Post Office Box 856, Concord, New Hampshire 03301. Telephone No. (603) 271-3254.
- f. Operator. The dam is maintained and operated by Pillsbury State Park, under the State of New Hampshire Resources and Economic Development Department, Division of Parks and Recreation, Post Office Box 856, Concord, New Hampshire 03301. Telephone No. (603) 271-3254.
- g. <u>Purpose of Dam.</u> The original purpose of the dam was to provide power to a mill. The present purpose of the dam is recreational.

- h. Design and Construction History. No information regarding the original design or construction of the dam was found. Early records indicate that it was last rebuilt in 1934. A set of plans dated 1934, showing plan, elevation, and section of an existing structure and proposed reconstruction prepared by R. D. Chapin, Civil Engineer, Newport, New Hampshire, are on file at the State of New Hampshire Water Resources Board. None of the details shown on these plans are consistent with the configuration of the present structure. Photographs taken in 1937 that are on file substantially agree with the detail of the present structure.
- i. Normal Operating Procedures. The Butterfield Pond Dam is used primarily to retain the waters of Butterfield Pond and adjoining May Pond for recreational use at Pillsbury State Park. There is no normal operating procedure for this dam.

#### 1.3 Pertinent Data

- a. <u>Drainage Area.</u> The drainage area above the Butterfield Pond Dam covers nearly 7.15 square miles (approximately 4576 acres), consisting of steeply sloped terrain surrounding Butterfield Pond and adjoining May Pond, and other smaller ponds located upstream from Butterfield Pond. The topography in the drainage basin ranges from 2332 feet (NGVD) on top of Bean Mountain to approximately 1592 feet (NGVD) at the base of the dam. The majority of the basin is heavily wooded and generally undeveloped. The development which does exist consists of structures associated with Pillsbury State Park.
- b. <u>Discharge at Damsite</u>. Discharge at the damsite normally occurs over the overflow section located between the two concrete training walls. A 16.2 feet wide by 0.2 foot deep low flow spillway is located near the middle of the overflow section. The invert of the spillway weir is at elevation 1603.0 feet (NGVD) and has a capacity of nearly 4 cfs. A 6.1 foot wide by 6.05 foot high sluice gate is located adjacent to the right training wall. The sluice gate is normally closed, and presently is inoperable and leaking through a split in the gate. This gate, if operable, would allow the reservoir to be lowered to an elevation of 1595.2 feet.
- (1) The capacity of the sluice gate was estimated to be 435 cfs with the water surface at the top of dam (elevation 1604.2 feet) and 595 cfs with the water surface at the test flood elevation (elevation 1609.5 feet).
  - (2) Maximum known flood at damsite unknown
- (3) The ungated spillway capacity with the water surface elevation at the top of the dam (elevation 1604.2 feet) was estimated to be 160 cfs
- (4) The ungated spillway capacity with the water surface elevation at the test flood elevation (elevation 1609.5 feet) was estimated to be 2,375 cfs

- (5) N/A
- (6) N/A
- (7) The total spillway capacity at the test flood elevation was estimated to be 2,375 cfs at 1609.5 elevation
- (8) The total project discharge at the top of the dam was estimated to be 210 cfs at 1604.2 elevation (with the sluice gate closed) and 630 cfs at 1604.2 elevation (with the sluice gate open)
- (9) The total project discharge at the test flood elevation was estimated to be 5,430 cfs at 1609.5 elevation
- c. <u>Elevation</u> (feet, NGVD) based on elevation 1603.0 shown on U.S.G.S. quad sheet assumed to be pool elevation at top of permanent spillway crest
  - (1) Streambed at toe of dam 1591.9
  - (2) Bottom of cutoff unknown
  - (3) Maximum tailwater unknown
  - (4) Recreation pool 1603.2
  - (5) Full flood control pool N/A
  - (6) Spillway crest 1603.0
  - (7) Design surcharge (Original Design) unknown
  - (8) Top of dam 1604.2
  - (9) Test flood design surcharge 1609.5
  - d. Reservoir (length in feet) (Butterfield Pond and adjoining May Pond)
    - (1) Normal pool 6,565
    - (2) Flood control pool N/A
    - (3) Spillway crest pool 6,550
    - (4) Top of dam 6,630
    - (5) Test flood pool 6,990

- e. Storage (acre-feet) (Butterfield Pond and adjoining May Pond)
  - (1) Normal pool 465
  - (2) Flood control pool N/A
  - (3) Spillway crest pool 440
  - (4) Top of dam 590
  - (5) Test flood pool 1,415
- f. Reservoir Surface (acres) (Butterfield Pond and adjoining May Pond)
  - (1) Normal pool 126
  - (2) Flood control pool N/A
  - (3) Spillway crest 125
  - (4) Test flood pool 175
  - (5) Top of dam 134
- g. Dam
  - (1) Type stone-filled gravity structure with concrete capped overflow section
  - (2) Length 210 feet overall
  - (3) Height 12.5 feet maximum
  - (4) Top Width 6.0 feet (at stone embankments) 8.0 feet (at overflow section)
  - (5) Side Slopes 1.5 V to 1.0 H downstream slope (left embankment) 1.0 V to 2.0 H downstream slope (right embankment)
  - (6) Zoning unknown
  - (7) Impervious core unknown
  - (8) Cutoff unknown
  - (9) Grout curtain none
  - (10) Other none

#### h. <u>Diversion and Regulating Tunnel</u>

Not applicable (see Section j below)

#### i. Spillway

- (1) Type stone fill, concrete capped overflow section with concrete training walls
  - (2) Length of weir 57 feet (entire overflow section)
    16.2 feet (low flow spillway section)
  - (3) Crest elevation 1603.0 (invert low flow spillway)
    1603.2 (invert main overflow section)
  - (4) Gates N/A
- (5) U/S Channel The banks of Butterfield Pond and May Pond are tree lined. For the most part the slopes appear to be stable, although some debris has blocked the sluice gate. Other than the debris blocking the sluice gate, no evidence of significant sedimentation was observed.
- (6) D/S Channel. The dam's overflow section discharges into a natural river channel (Ashuelot River) which is about 20 feet wide and 3.5 feet deep. Approximately 350 feet downstream from the dam, the river passes beneath a state highway (NH Route 31). The bridge opening (perpendicular to the centerline of the channel) measures 24.3 feet wide by 10.4 feet high. After passing through the bridge, the river travels in a southerly direction until it discharges into Ashuelot Pond, approximately 6 miles downstream from the dam.

#### j. Regulating Outlets

- (1) Invert Sluice gate 1595.2 (bottom of gate opening)
- (2) Size Sluice gate 6.1 feet wide x 6.05 feet high opening
- (3) Description Sluice gate 5 inch thick wooden planks, 7.1 feet wide, bolted together to form gate in 6.1 feet wide opening
- (4) Control Mechanism Sluice gate Manual crank lift by cables.

  Lifting mechanism removed. Gate planks split and leaking.

#### SECTION 2 ENGINEERING DATA

#### 2.1 Design

No design data were disclosed for Butterfield Pond Dam. A set of plans dated 1934 showing plan, elevation, and section of an existing structure and proposed reconstruction of the dam by R.D. Chaplin, Civil Engineer, Newport, New Hampshire are on file at the State of New Hampshire Water Resources Board. None of the details shown on those plans were consistent with the configuration of the present structure.

#### 2.2 Construction

No construction records were disclosed.

#### 2.3 Operation

No engineering operational data were found.

#### 2.4 Evaluation

- a. Availability. No engineering data were available for Butterfield Pond Dam. A search of the files of the State of New Hampshire Water Resources Board revealed a limited amount of recorded information.
- b. Adequacy. The final assessments and recommendations of this investigation are based on the visual inspection and the hydrologic and hydraulic calculations.
- c. <u>Validity</u>. The field investigation indicated that the external features of the Butterfield Pond Dam almost completely disagree with the detail shown on the plans on file at the State of New Hampshire Water Resources Board.

#### SECTION 3 VISUAL INSPECTION

#### 3.1 Findings

a. General. Butterfield Dam impounds a pond of small size. The drainage area above the dam consists of steeply sloped terrain surrounding Butterfield Pond and adjoining May Pond, and other smaller ponds located upstream from Butterfield Pond. The majority of the basin is heavily wooded and generally undeveloped. The development which does exist consists of structures associated with Pillsbury State Park. The downstream area is undeveloped except for the bridge crossing of NH State Route 31.

The field inspection of Butterfield Pond Dam was made on December 6, 1979. The inspection team consisted of personnel from S E A Consultants Inc. and Geotechnical Engineers, Inc. Inspection checklists, completed during the visual inspection, are included in Appendix A. At the time of inspection, water was passing approximately 2-1/2 inches deep over the 16.2 feet wide low flow spillway. The pool elevation was at approximately 1603.2 feet (NGVD). The upstream face of the dam could only be inspected above this water level.

b. <u>Dam.</u> Butterfield Pond Dam is a stone-filled gravity structure about 210 feet in overall length and 12.5 feet high from crest of dam to toe of slope. (See Plans and Detailing in Appendix B.)

The central portion of the dam consists of a stone-masonry overflow section about 57 feet long with concrete training walls and a stone weir, concrete capped on the crest and downstream side. (See Photo Nos. 2 and 7.) The crest of the overflow section is about 8 feet wide and the downstream face is vertical. (See Photo Nos. 3 and 7.) The upstream side of the overflow section is not completely visible beneath the water surface, but does indicate the existence of an unmortared stone apron. Located near the middle of the overflow section cast into the concrete cap is the low flow spillway which is 16.2 feet wide and 0.2 feet deep. (See Photo Nos. 7 and 8.) The concrete cap on the crest of the overflow section is broken and severely eroded at numerous locations. (See Photo Nos. 8 and 10.) At one location there is a small eddy where water is flowing down into a hole on the crest. Water is leaking from the downstream face at the contact between the overflow section and the foundation bedrock. (See Photo No. 9.) Major leakage is discharging from loose rocks at the toe of the right end of the overflow section.

Between the sluice gate at the right training wall of the overflow section and the right abutment, there is a stone embankment which appears to consist of a vertical dry-stone-masonry wall with earthfill against the upstream and downstream sides. In the fill immediately adjacent to the upstream side of the wall, there is a ditch in which water is flowing from the pond toward a sinkhole which is about 15 to 20 feet to the right of the concrete sluice gate structure. (See Plans and Details in Appendix B.) It appears that the water which flows into this sinkhole is discharging at the base of the downstream end of the right training wall of the sluice gate structure. (See Photo No. 13.) About 5 feet to the right of the concrete sluice gate structure, the crest of the stone embankment has subsided about 2 feet. Directly in line with this subsidence, there is an apparent erosion channel that

extends from the crest to the toe of the downstream slope of the embankment. This channel is filled with weeds and brush, and there are stumps of some small trees in the channel. Some brush and one small tree are growing on the earthfill on the upstream side of the stone embankment. Brush and weeds are growing on the earthfill on the downstream side of the stone embankment. (See Photo No. 4.)

Between the left training wall of the overflow section and the left abutment there is a stone embankment which has a downstream slope inclined at about 1.5V:1H and which has an earthfill against its upstream side. There appears to be a major bulge in the downstream slope of this stone embankment close to the overflow section of the dam. (See Photo No. 5.) Major seepage is discharging at the toe of the stone embankment next to the overflow section. The crest of the stone embankment has settled about 1 to 1 1/2 feet within about 10 feet of the overflow section and the crest of the earthfill on the upstream side of the embankment has a sinkhole about 3 to 4 feet deep above pond level at a location about 25 feet to the left of the overflow section. (See Photo No. 6.) Brush and small trees are growing on the earthfill on the upstream side of the embankment. Brush and trees are growing at the downstream toe of the embankment. (See Photo No. 4.)

c. Appurtenant Structures. Located at the right training wall of the overflow section is the dam's outlet structure which consists of a reinforced concrete sluice gate structure that discharges into a 12 foot wide stone-lined sluiceway that extends approximately 56 feet to the main channel. (See Photo Nos. 10 and 11.) The sluice gate itself consists of 5-inch thick wood planks that are secured together by two long vertical bolts. The gate is approximately 6.1 feet wide and 6.05 feet high and is raised and lowered through steel slots embedded in the sides of the concrete sluice gate structure. Near the top of the gate, a severe crack has developed between the wood planks and water is pouring through and discharging into the sluiceway. (See Photo No. 12.)

A 6-inch thick concrete slab cast on top of the sluice gate structure acts as a control tower for the gate. The lifting mechanism has been removed, and the gate is jammed in the closed position. The upstream face of the left wall of the concrete sluice gate structure is being undermined and is deteriorated, exposing reinforcing steel.

- d. Reservoir Area. The slopes of the ponds appear to be stable. No evidence of significant sedimentation was observed. The approach channel to the spillway is wide and unobstructed.
- e. <u>Downstream Channel</u>. The dry-stone-masonry wall on the right side of the sluiceway downstream of the sluice gate structure is in poor condition. Some brush is growing in the channel downstream of the sluiceway. Some trees overhang the channel downstream of the overflow section of the dam, and one tree has blown over across the channel. (See Photo Nos. 14, 15 and 16.)

#### 3.2 Evaluation

On the basis of the results of the visual inspection, Butterfield Pond Dam is considered to be in very poor condition.

A major sinkhole into which water from the pond is flowing on the upstream side of the stone embankment at the right end of the dam, subsidence of the crest of the right stone embankment, an apparent erosion channel on the downstream slope of the right embankment, and a major discharge of water from the base of the right training wall of the sluice gate structure are all signs of serious stability problems of the right embankment. It is possible that this embankment could fail at any time.

A major subsidence of the crest of the stone embankment at the left end of the dam, a major sinkhole in the earthfill on the upstream side of the left stone embankment, apparent bulging of the downstream slope of the left embankment, and a major discharge of water from the downstream toe of the left embankment are all signs of serious stability problems of the left embankment. It is possible that this embankment could fail at any time.

The broken and eroded condition of the concrete cap and downstream facing of the overflow section of the dam, leakage from cracks in the downstream facing, leakage at the contact between the overflow section of the dam and the bedrock foundation, and the flow of pond water into a hole on the crest of the overflow section are all signs of serious stability problems in the overflow section of the dam.

A large crack between the wood planks of the sluice gate and the water pouring through and discharging into the sluiceway, and the absence of any lifting mechanism are signs of considerable deterioration of the gate. It is possible that the gate could fail at any time.

Trees growing at the downstream toe of the dam, and brush which will eventually attain tree-size on the earthfills on the upstream side of the left stone embankment and on the upstream and downstream sides of the right stone embankment may lead to erosion and seepage problems if a tree blows over and pulls out its roots, or if a tree dies or is cut and its roots rot.

# SECTION 4 OPERATIONAL AND MAINTENANCE PROCEDURES

#### 4.1 Operational Procedures

- a. General. The Butterfield Pond Dam is used primarily to retain the waters of Butterfield Pond and adjoining May Pond. There are no written or routine operational procedures.
- b. <u>Description of Any Warning System in Effect.</u> No written warning system exists for the dam.

#### 4.2 Maintenance Procedures

- a. General. The owner, the New Hampshire Resources and Economic Development Department, Division of Parks and Recreation, is responsible for the maintenance of the dam. No formal plan for maintenance was discussed.
- b. Operating Facilities. No formal plan for maintenance of operating facilities was disclosed.

#### 4.3 Evaluation

The current operation and maintenance procedures for the Butterfield Pond Dam are inadequate to insure that all problems encountered can be remedied within a reasonable period of time. The owner should establish a written operation and maintenance procedure, as well as establish a warning system to follow in event of flood flow conditions or imminent dam failure.

# SECTION 5 EVALUATION OF HYDROLOGIC/HYDRAULIC FEATURES

5.1 General. Butterfield Pond Dam is a stone-filled gravity structure approximately 210 feet in overall length and 12.5 feet high from crest of dam to toe of slope. Located near the center of the dam is the principal overflow section which is 57 feet long and consists of a concrete capped, stone weir with concrete training walls. Near the middle of the overflow section is a 16.2 feet wide by 0.2 foot deep low flow spillway weir. Adjacent to the right training wall of the overflow section is a 6.1 feet wide by 6.05 feet high sluice gate housed in a reinforced concrete structure. The sluice gate discharges into a 12 feet wide stone-lined sluiceway which extends approximately 56 feet to the main channel. At this time, the wooden plank sluice gate is inoperable and is severely leaking through a gap between two of the planks.

In addition to Butterfield Pond, five other ponds are located in the drainage area upstream from Butterfield Pond. Consequently, nearly two-thirds of the runoff from the watershed is intercepted by these ponds before flowing into Butterfield Pond.

- 5.2 Design Data. No hydrological or hydraulic design data were disclosed.
- 5.3 Experience Data. No experience data were disclosed. Maximum flood flows or elevations are unknown.
- 5.4 Test Flood Analysis. Due to the absence of detailed design and operational information, the hydrologic evaluation was performed utilizing data gathered during field inspection, watershed size and an estimated test flood determined from the Corps of Engineers guide curves. For this dam (small size and significant hazard) the test flood ranges from a 100-Year Flood to one-half the Probable Maximum Flood (1/2 PMF). Due to the very poor condition of the dam the 1/2 PMF was selected for this analysis. Since the drainage area consists of steeply sloping terrain, the "mountainous" curve, from the Corps of Engineers set of guide curves, was used to estimate the maximum probable peak flow rate.

Based on an estimated maximum probable flood peak flow rate of 2,100 cfs per square mile and a drainage area of 7.15 square miles, the test flood inflow was estimated to be 7,500 cfs. The test flood was routed through the reservoir in accordance with the Corps of Engineers procedure for Estimating Effect of Surcharge Storage on Maximum Probable Discharge. The routed test flood outflow was estimated to be 5,430 cfs. This analysis indicated that the dam crest would be overtopped by approximately 5.3 feet. The maximum spillway capacity (assuming that the sluice gate is closed) with the water level at the dam crest was estimated to be 160 cfs, which is only about 3 percent of the routed test flood outflow.

5.5 <u>Dam Failure Analysis</u>. The impact of dam failure with the reservoir surface at the dam crest was assessed utilizing the "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs published by the Corps of Engineers. The analysis covered a reach extending approximately 6 miles downstream to Ashuelot Pond. Based on this analysis, the Butterfield Pond Dam has been classified as a significant hazard.

Failure of the Butterfield Pond Dam would increase the stage along the immediate downstream channel by 7.5 feet, with an associated discharge of 5,950 cfs. Since this discharge exceeds the capacity of the highway bridge by nearly 2,000 cfs, it is probable that the pool formed by the flow restriction of the bridge would overtop the roadway by 2 to 3 feet and could cause significant damage to the bridge and roadway. The stage of the river would be reduced to about 4.5 feet by the time it discharges into Ashuelot Pond. The stage, however, would decrease rapidly, to less than a foot, as the flow passes through the wider portions of the pond. Although the potential for loss of life would exist if the bridge were to wash out, no loss of life is anticipated.

# SECTION 6 EVALUATION OF STRUCTURAL STABILITY

#### 6.1 Visual Observations

The visual inspection indicates the following potential structural problems:

- (1) A major sinkhole into which water from the pond is flowing on the upstream side of the stone embankment at the right end of the dam, subsidence of the crest of the right stone embankment, an apparent erosion channel on the downstream slope of the right embankment, and a major discharge of water from the base of the right training wall of the sluice gate structure are all signs of serious stability problems in the right embankment. It is possible that this embankment could fail at any time.
- (2) A major subsidence of the crest of the stone embankment at the left end of the dam, a major sinkhole in the earthfill on the upstream side of the left stone embankment, apparent bulging of the downstream slope of the left embankment, and a major discharge of water from the downstream toe of the left embankment are all signs of serious stability problems in the left embankment. It is possible that this embankment could fail at any time.
- (3) The broken and eroded condition of the concrete cap and downstream facing of the overflow section of the dam, leakage from cracks in the downstream facing, leakage at the contact between the overflow section of the dam and the bedrock foundation, and the flow of pond water into a hole on the crest of the overflow section are all signs of serious stability problems in the overflow section of the dam.
- (4) The large crack between the wood planks of the sluice gate and the water pouring through and discharging into the sluiceway, and the absence of any lifting mechanism are signs of considerable deterioration of the gate. It is possible that the gate could fail at any time.
- (5) Trees growing at the downstream toe of the dam, and brush which will eventually attain tree-size on the earthfills on the upstream side of the left stone embankment and on the upstream and downstream sides of the right stone embankment, may lead to erosion and seepage problems if a tree blows over and pulls out its roots, or if a tree dies or is cut and its roots rot.

#### 6.2 Design and Construction Data

No information regarding the original design or construction of the dam was found.

#### 6.3 Post-Construction Changes

Early records indicate that the dam was rebuilt in 1934. A set of plans dated 1934, showing plan, elevation, and section of an existing structure and proposed reconstruction prepared by R.D. Chapin, Civil Engineer, Newport, New Hampshire, are on file at the New Hampshire Water Resources Board. None of the detail shown on these plans are consistent with the configuration of the present structure. Photographs taken in 1937 that are on file substantially agree with the detail of the present structure.

#### 6.4 Seismic Stability

This dam is located in Seismic Zone 2 and, in accordance with the Phase I guidelines, does not warrant seismic analysis.

# SECTION 7 ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

#### 7.1 Dam Assessment

- a. <u>Condition</u>. The visual examination indicates that Butterfield Pond Dam is in very poor condition. The major concerns with respect to the integrity of the dam are:
  - (1) Sinkhole in the earthfill on the upstream side of the right stone embankment, with pond water flowing into the sinkhole.
  - (2) Major subsidence of the crest of the left stone embankment.
  - (3) Bulging of the downstream slope of the left stone embankment.
  - (4) Severely broken and eroded condition of the concrete cap and the downstream concrete facing of the overflow section.
  - (5) Leakage from cracks in the downstream facing of the overflow section and at the contact between the overflow section and the foundation bedrock.
  - (6) Subsidence of the crest of the right stone embankment.
  - (7) Erosion channel from the crest to downstream toe of the right embankment.
  - (8) Major seepage at the base of the right training wall of the sluice gate structure.
  - (9) Sinkhole above pond level in the earthfill on the upstream side of the left stone embankment.
  - (10) Major seepage at the downstream toe of the left embankment.
  - (11) Leakage through a large crack between the wood planks of the sluice gate.
  - (12) Trees overhanging the discharge channel downstream of the overflow section of the dam and one tree which has blown over across the channel.
  - (13) Inadequacy of the spillway to pass the test flood.

- b. Adequacy of Information. The information available from the visual inspection is adequate to identify the problems that are listed in 7.2. These problems will require the attention of a qualified registered professional engineer who will have to make additional engineering studies to design or specify remedial measures. No additional information is needed for the purpose of this Phase I investigation.
- c. <u>Urgency.</u> The owner should implement the recommendations in 7.2 and 7.3 immediately upon receipt of this Phase I report.

#### 7.2 Recommendations

The owner should retain a registered professional engineer qualified in the design and construction of dams to:

- (1) Investigate the sinkhole, crest subsidence, erosion channel on the downstream slope, and seepage at the left end of the right stone embankment, and design remedial measures as needed.
- (2) Investigate the subsidence of the crest, sinkhole in the upstream earthfill, bulging of the downstream slope, and seepage at the downstream toe of the left stone embankment, and design remedial measures as need
- (3) Investigate the structural condition of the overflow section and design remedial measures as needed.
- (4) Investigate the structural condition of the sluice gate and design remedial measures as needed.
- (5) Do a detailed hydrologic-hydraulic investigation to assess further the potential of overtopping the dam, the adequacy of the spillway to pass the test flood, and the need for and means to increase project discharge capacity.

The owner should carry out the recommendations made by the engineer.

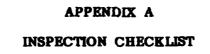
#### 7.3 Remedial Measures

- a. Operating and Maintenance Procedures. The owner should:
  - (1) Clear brush and trees from a zone 25 feet wide on each side of the discharge channel between the dam and the highway bridge downstream of the dam.
  - (2) Visually inspect the dam and appurtenant structures once a month.
  - (3) Engage a registered professional engineer qualified in the design and construction of dams to make a comprehensive technical inspection of the dam once every year.

(4) Establish a surveillance program for use during and immediately after heavy rainfall, and also a warning program to follow in case of emergency conditions.

#### 7.4 Alternatives

There are no practical alternatives to the recommendations of Section 7.2 and 7.3 except removal of the dam.



# INSPECTION CHECK LEST PARTY ORGANIZATION

OJECT: Butterfield Pond Dam, NH	DATE: December 6, 1979  TIME: 9:00 a.m.  WEATHER: Cool, partly cloudy  W.S. ELEV. 1603.2 U.S. 1591.9DN.S.  (NGVD)
RTY:  Kenneth Stewart, S E A  Robert Durfee, S E A  Bruce Pierstorff, S E A  Philip Ricardi, S E A  Ronald Hirschfeld, GEI	6. Kenneth Stern, NHWRB  7. Richard DeBood, NHWRB  8.  9.
PROJECT FEATURE Structural Stability	INSPECTED BY REMARKS K. Stewart/R. Durfee
Hydrology/Hydraulics	B. Pierstorff/P. Ricardi
Soils and Geology	
· · · · · · · · · · · · · · · · · · ·	
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## INSPECTION CHECK LIST PROJECT: \_Butterfield Pond Dam, NH\_\_\_\_\_ DATE: December 6, 1979 PROJECT FEATURE: Dam Embankment NAME: DISCIPLINE: NAME: AREA EVALUATED CONDITIONS DAM EMBANKMENT Crest Elevation 1603.0 Current Pool Elevation 1603.2 Maximum Impoundment to Date Unknown Surface Cracks None observed Pavement Condition Not paved Movement or Settlement of Crest One sinkhole in crest to right of sluice gate structure, one sinkhole in crest near left end of overflow section Lateral Movement Bulging of downstream dry stone masonry wall between left end of overflow section and left abutment in vicinity of sinkhole on crest Vertical Alignment Sinkholes, as noted above Horizontal Alignment See "Lateral Movement" above Condition at Abutment and at Concrete Structures Fair Indications of Movement of Structural Items on Slopes None observed Trespassing on Slopes No evidence observed Vegetation on Slopes Brush and some small trees on upstream side of embankment, on abutments, and downstream of toe of dam Sloughing or Erosion of Slopes or Abutments Major erosion channel on downstream slope next to training wall on right side of sluiceway Rock Slope Protection - Riprap Failures No riprap Unusual Movement or Cracking at or near Toe None observed Unusual Embankment or Downstream Seepage Major seepages at several locations Piping or Boils None observed None observed Foundation Drainage Features None observed Toe Drains Instrumentation System None observed

INSPECTION CHECK LIST				
PROJECT: Butterfield Pond Dam, NH	DATE: December 6, 1979			
PROJECT FEATURE: Dike Embankment	NAME:			
DISCIPLINE:	NAME:			
AREA EVALUATED	CONDITIONS			
DIKE EMBANKMENT	No dike			
Crest Elevation				
Current Pool Elevation				
Maximum Impoundment to Date				
Surface Cracks				
Pavement Condition				
Movement or Settlement of Crest				
Lateral Movement				
Vertical Alignment				
Horizontal Alignment				
Condition at Abutment and at Concrete Structures				
Indications of Movement of Structural Items on Slopes				
Trespassing on Slopes				
Vegetation on Slopes				
Sloughing or Erosion of Slopes or Abutments				
Rock Slope Protection - Riprap Failures				
Unusual Movement or Cracking at or near Toe				
Unusual Embankment or Downstream Seepage				
Piping or Boils				
Foundation Drainage Features				
Toe Drains				
Instrumentation System				

INSPECTION CHECK LIST				
PROJECT: Butterfield Pond Dam, NH	DATE: December 6, 1979			
PROJECT FEATURE: Intake Channel	NAME:			
DISCIPLINE:	NAME:			
AREA EVALUATED	CONDITIONS			
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE				
a. Approach Channel				
Slope Conditions	Good			
Bottom Conditions	Not visible beneath pond surface			
Rock Slides or Falls	None			
Log Boom	None			
Debris	Debris built up against sluice gate			
Condition of Concrete Lining	Loose stone lining			
Drains or Weep Holes	None			
b. Intake Structure				
Condition of Concrete	Fair to poor. Exposed reinforcing steel and numerous cracks.			
Stop Logs and Slots	Wooden gate (not operable) split and leaking.			

INSPECTION CHECK LIST			
PROJECT: Butterfield Pond Dam, NH	DATE: December 6, 1979		
PROJECT FEATURE: Control Tower	NAME:		
DISCIPLINE:	NAME:		
AREA EVALUATED	CONDITIONS		
OUTLET WORKS - CONTROL TOWER			
a. Concrete and Structural			
General Condition	Fair		
Condition of Joints	Good		
Spalling	Minor		
Visible Reinforcing	Visible reinforcement on leading edge of both sides of intake channel		
Rusting or Staining of Concrete	Minor		
Any Seepage or Efflorescence	Minor		
Joint Alignment	Good		
Unusual Seepage or Leaks in Gate Chamber	None observed		
Cracks	Numerous		
Rusting or Corrosion of Steel	Rusting of visible reinforcing steel		
b. Mechanical and Electrical			
Air Vents	Not applicable		
Float Wells	Not applicable		
Crane Hoist	None		
Elevator	Not applicable		
Hydraulic System	Not applicable		
Service Gates	Not accessible - water pouring through apparent split in wooden gate		
Emergency Gates	Same as service gates		
Lightning Protection System	Not applicable		
Emergency Power System	Not applicable		
Wiring and Lighting System	Not applicable		

INSPECTION CHECK LIST					
PROJECT: Butterfield Pond Dam, NH	DATE: December 6, 1979				
PROJECT FEATURE: Transition and Conduit					
DISCIPLINE:					
AREA EVALUATED	CONDITIONS				
OUTLET WORKS - TRANSITION AND CONDUIT	Not applicable				
General Condition of Concrete					
Rust or Staining on Concrete					
Spalling					
Erosion or Cavitation					
Cracking					
Alignment of Monoliths					
Alignment of Joints					
Numbering of Monoliths					

INSPECTION CHECK LIST				
PROJECT: Butterfield Pond Dam, NH	DATE: December 6, 1979			
PROJECT FEATURE: Outlet Structure	NAME:			
DISCIPLINE:	NAME:			
AREA EVALUATED CONDITIONS				
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL				
General Condition of Concrete	Fair			
Rust or Staining	Minor			
Spalling	Minor			
Erosion or Cavitation	Both wing walls undermined and eroded. (Left side more serious.)			
Visible Reinforcing	None observed			
Any Seepage or Efflorescence	Some efflorescence			
Condition at Joints	Cracking at lift boundaries			
Drain holes	None			
Channel				
Loose Rock or Trees Overhanging Channel	Trees overhanging channel. Dry stone masonry wall on the right side of the sluiceway channel is in poor condition.			
Condition of Discharge Channel	Fair			

INSPECTION CHECK LIST					
PROJECT: Butterfield Pond Dam, NH	DATE: December 6, 1979				
PROJECT FEATURE: Spillway Weir	NAME:				
DISCIPLINE:					
AREA EVALUATED	CONDITIONS				
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS					
a. Approach Channel					
General Condition	Good				
Loose Rock Overhanging Channel	None observed				
Trees Overhanging Channel	None observed				
Floor of Approach Channel	Not visible beneath pond surface				
b. Weir and Training Walls					
General Condition of Concrete	Extensively deteriorated				
Rust or Staining	None observed				
Spalling	Large sections of concrete cap broken away				
Any Visible Reinforcing	None				
Any Seepage or Efflorescence	Extensive seepage				
Drain Holes	None				
c. Discharge Channel					
General Condition	Fair				
Loose Rock Overhanging Channel	None observed				
Trees Overhanging Channel	Trees in channel and overhanging channel				
Floor of Channel	Boulder-covered				
Other Obstructions	One tree has fallen across channel				

INSPECTION CHECK LIST				
PROJECT: Butterfield Pond Dam, NH	DATE: December 6, 1979			
PROJECT FEATURE: Service Bridge	NAME:			
DISCIPLINE:	NAME:			
AREA EVALUATED CONDITIONS				
OUTLET WORKS - SERVICE BRIDGE	No service bridge			
a. Super Structure				
Bearings				
Anchor Bolts				
Bridge Seat				
Longitudinal Members				
Under Side of Deck				
Secondary Bracing				
Deck				
Drainage System				
Railings				
Expansion Joints				
Paint				
b. Abutment & Piers				
General Condition of Concrete				
Alignment of Abutment				
Approach to Bridge	·			
Condition of Seat & Backwall				

APPENDIX B

ENGINEERING DATA

# AVAILABLE ENGINEERING DATA

No Engineering Data other than past inspection reports from the State of New Hampshire Water Resource Board were available.

PAST INSPECTION REPORTS

December 7, 1979

To: Vern Knowlton

From: Ken Stern 5

Re: Corps Inspection of May Pond Dam

(Butterfield Dam) 245.01, Washington

On December 6, 1979 I accompanied the inspection team from SEA Consultants. This dam is in poor condition. The concrete is extremely deteriorated, the rock abutments have settled, there is major leakage at several locations.

The only structure threatened should the dam fail is a highway bridge on state route 31. This bridge has a large clear opening. If the dam were to fail gradually there may be no damage to the bridge.

I discussed the dam with Gary, who has been there, and we agree that major reconstruction is needed. Once work is considered, total reconstruction may be inevitable.

I recommend that the stoplogs be removed and the pond lowered until remedial action is taken. This would reduce the hydraulic pressure on the dam and reduce the amount of water discharged should the dam fail. The lowered water level would redistribute the location and magnitude of the ice pressures on the structure.

I recommend lowering the pond. A decision should be made and action taken now.

KS/1n

## May Pond, Dam No. 245.01, Washington, New Hampshire

This is a stone-fill, gravity with concrete abutments and spillway cap dam type structure. It is approximately 225' long and with a maximum height of 18'. The present structure has several serious leaks through the stonework, and cracks and holes in the concrete. It also contains a pond drain gate near the base of the dam which also leaks. The present configuration of the dam and spillway does not permit the passage of the estimated 100 year flood flow (1,450cfs) without the dam being overtopped. The Board's proposal includes work to stop the leakage and increase the discharge capacity to equal the 100 year flood flows.

The proposal incorporates constructing an access road, removing the leaking spillway stones and concrete cap, the leaking gate section abutments, constructing steel reinforced concrete face walls and abutments, and a new concrete spillway with flashboards. This will require the removal of accumulated silt and debris from the upstream side of the dam. The project also includes constructing a stoplog section to act as a pond drain which may require some channel excavation to improve the hydraulics of the downstream channel.

The attached cost estimate reflects the materials of construction and labor costs of this proposal to be constructed not later than the end of 1980.

### MAY POND DAM (#245.01)

### WASHINGTON, NEW HAMPSHIRE

- 1. Dam originally constructed to create a mill pond, but now used to maintain a recreation pond for users of Pillsbury State Park
- 2. Pond area 103 Acres
- 3. Ratio of net drainage to pond area 37:1
- 4. 100 year flood flows 1450 cfs
- 5. Shoreline 3± Miles
- 6. Altitude 1632 feet
- 7. Watershed Connecticut
- 8. River system Ashuelot River
- 9. Inlets Ashuelot River
- 10. Color of water colorless
- 11. Ownership- State, Division of Parks

#### MAY POND DAM (#245.01)

### PILLSBURY STATE PARK

### WASHINGTON, N. H.

At the present time, the dam on May Pond does not have capacity to flow the 100 year storm frequency flow without overtopping the dam. The present design standard requires dams to pass storms equal to 100 year frequency flood flows. The dam also has several serious leaks through the stonework.

# The design for this project includes:

- 1. Removing existing spillway and construction a permanent concrete crest with automatic flashboards.
- 2. Stoplog section construction.
- 3. New concrete abutments and cut-off and upstream face walls to prevent the leak which is now occurring.

## The follwing is a cost estimate:

1.	Access Road		\$ 8,000.00
2.	Remove cut brush and grass		2,000.00
3.	Remove existing stone spillway, deb and silt	10,000.00	
4.	Concrete, reinforcements, etc. (20	00 су)	70,000.00
5.	Stoplog construction		8,000.00
6.	Backfill & clean-up		6,000.00
	•	SUB-TOTAL	\$104,000.00
	20% Engineering & Contingencies		20,800.00
		TOTAL	\$124,800.00
		ROUNDED TOTAL	\$125,000.00

#### MEMO

TO: Vernon A. Knowlton

Chief Engineer

DATE: August 16, 1978

FROM: Gary Kerr

Water Resources Engineer

SUBJECT: Dam Inspection #245.01 - Report of Leakage

DATE OF INSPECTION: August 14, 1978

Via a letter from the S.C.S. office in Claremont I was instructed to reinspect the subject dam for a serious leak. Below are listed my observations and please refer to the accompaning photos and file for clarity.

- 1. Dam is founded on ledge and consists of piled stones embankment and spillway with a concrete cap.
- 2. A stoplog section with concrete abutments.
- 3. Serious leakage occuring them the structure at several places:
  - a. Right embankment
  - b. Left side pier of the stoplog section
    - c. Thru the hole in the spillway cap

This structure is listed as a menace dam because of the pondage (approx. 103 acres) DA of 7.3  $m_1^2$  and downstream development.

The Ashuelot River flows thru May Pond, under Route 31 and into Ashuelot Pond, Washington. There is considerable domestic development around Ashuelot Pond and points South.

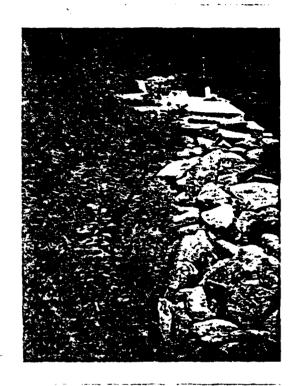
In F.C.M.'s inspection report of 1971, he states that the dam's flood capacity is sufficient to pass the estimated 100 flood with 1/2 of freeboard and no gate (now stoplogs) operation. He also indicated "it appeared (through openings in the snow) to be well built, substantial, and water tight.' Unfortunately now, these assumptions are not entirely true. The dam has deteriorated, rocks have moved, the spillway cap is broken and the structure does leak seriously.

I strongly suggest that the pond be lowered or the dam sealed, sufficiently enough to stop the leakage thru the embankment and spillway cap. This may require a drawdown of 2-3', and since we are approching the hurricane season, the drawdown would redue the protential flooding of a full pond plus runoff from the strom should the dam fail.

CLK/kn

MAY POND DAM # 245.01

HEAT STOUZ EMBOUKHENT ARBOILS DENGTE FLOW PATHS





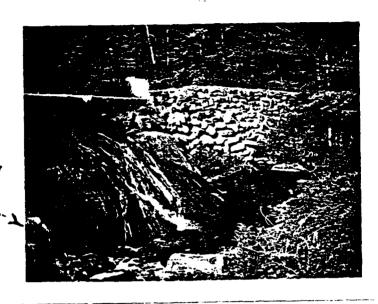
ENTRANCE PATH





EXIT AT BASE OF STONE

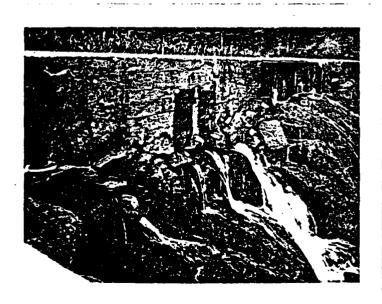
EMBANKMENT NEAR STOPLOG



LEAKAGE PROBAGY
FROM STODIOG
SECTION

HOLE IN SPILLWAY





EXIT FOR HOLE

# STATE OF NEW HAMPSHIRE

#### INTER-DEPARTMENT COMMUNICATION

DATE

August 16, 1978

FROM

George M. McGee, Sr.

Chairman

AT (OFFICE)

Water Resources Board

**SUBJECT** 

Leakage through dam #245.01 at May Pond

TO Theodore Natti, Director Division of Resources Development

This office has been alerted to the fact that your "Butterfield Dam" (245.01), at May Pond, Pillsbury State Park is leaking quite badly. An engineer re-inspected this dam and filed his report. Please be aware that this dam was inspected, per your request, in September, 1975 and a copy of the suggested repairs was sent to you. The inspector noted that none of the suggested repairs, short term or otherwise, were implamented and now the dam condition has deteriorated seriously.

As a result of this inspection the following items require your immediate attention:

- 1. The right hand piled stone embankment (looking downstream) no longer acts as a pond retaining structure as water freely flows through it.
- 2. This same embankment appears to have sloughed, to the extent that it no longer retains the shape of a stone wall with vertical sides.
- 3. Because of the present pond elevation and erosion on the upstream side of this embankment, leakage is occurring through the right hand embankment (please see photos).
- 4. Leakage is also freely flowing through the enlarged hole in the concrete spillway cap (please see photo).
- 5. Leakage is also evident adjacent to the left hand pier for the stoplog section on the downstream side of the spillway.

All of the above constitute a hazardous condition and threatens the stability of the dam and as such require corrective action.

Because this dam is a menace structure, we require that you send us a schedule of your proposed repairs within 30 days. We do suggest that you reduce the pond level 2-3 feet, or more, effectively immediately and remain lowered until your repairs are completed, or the causes of the leakage eliminated.

If you have any questions, please contact us.

Sincerely yours,

George M. McGee, Sr.

# N. H. WATER RESOURCES BOARD Concord, N. H. 03301

# DAM SAFETY INSPECTION REPORT FORM

TOWN: WASHINGTON	Dam Number: 245.01
Inspected by: GARY L. KEER	Date: 30 Sep 1975
Local name of dam or water body:	By Pown
Owner: PILLSBURY STATE PARK	Address:
Cwner was/was not interviewed during insp	ection.
Drainage Area: 601 sq. mi.	Stream: ASHUBIOT RIVER
Fond Area: 103 (FdG) cre, Stor	ageAc-Ft. Max. HeadFt.
	seepage present at toe - 100/No, No.
Spillway: Type <u>Concrete Car</u> , F	reeboard over perm. crest: Z't,
Width 40't, F	Flashboard height 3'± max,
Max. Capacity	c.f.s.
Embankment: Type Rock,	Cover Roccs Width 516,
	1; Downstream slope VERT to 1
Abutments: Type Concrete,	Condition: Fair
Gates or Pond Drain: Size 5 LONG	Capacity Type STOP LOSS
Lifting apparatus New	Operational condition YES WEVER
Changes since construction or last inspec	
Downstream development:	
This dam would would not be a menace if	it failed. With our Ed.
Suggested reinspection date:	·
Remarks: /foce in concerte	CAP OI SPILLWAY
MINOR FEDWAR OK ABU	TMELTS
APPER 2" FLOW OVER 5711	LUVAY

O/LMAC.

DATE: February 8, 1971

FRO M: Francis C. Moore, P.E.

Water Resources Engineer

SUBJECT: May Pond at Pillsbury State Park, Washington - #254.01

TO: Vernon A. Knowlton

Chief Water Resources Engineer

On January 25, 1971, I inspected the dam called Butterfield dam that flows back into May Pond in Washington at the head-waters of Ashuelot River. This dam was well rebuilt by C.C.C. forces in 1934, consisting of rock fill dam with concrete capped spillway.

The capacity of the spillway with 1/2 foot freeboard and no overflow through a 6' x 6' gate is once in 100 years. The dam appears, through openings in the snow, to be well built, substantial and vater tight. However, there may be some trees to be removed from dam (\$500.), some concrete patching (\$3,500.) and miscellaneous work (\$1,000.) totaling about \$5,000. upon inspection at a later time.

Two views are shown in photos taken at this dam. The gate section could be opened to lower the pond if necessary. This dam is near N. H. W. Route #31 midway between Washington and Goshen on the northeast side of the highway.

As seen in the photos, water was going an estimated 4" over the spillway.

FCM/jb



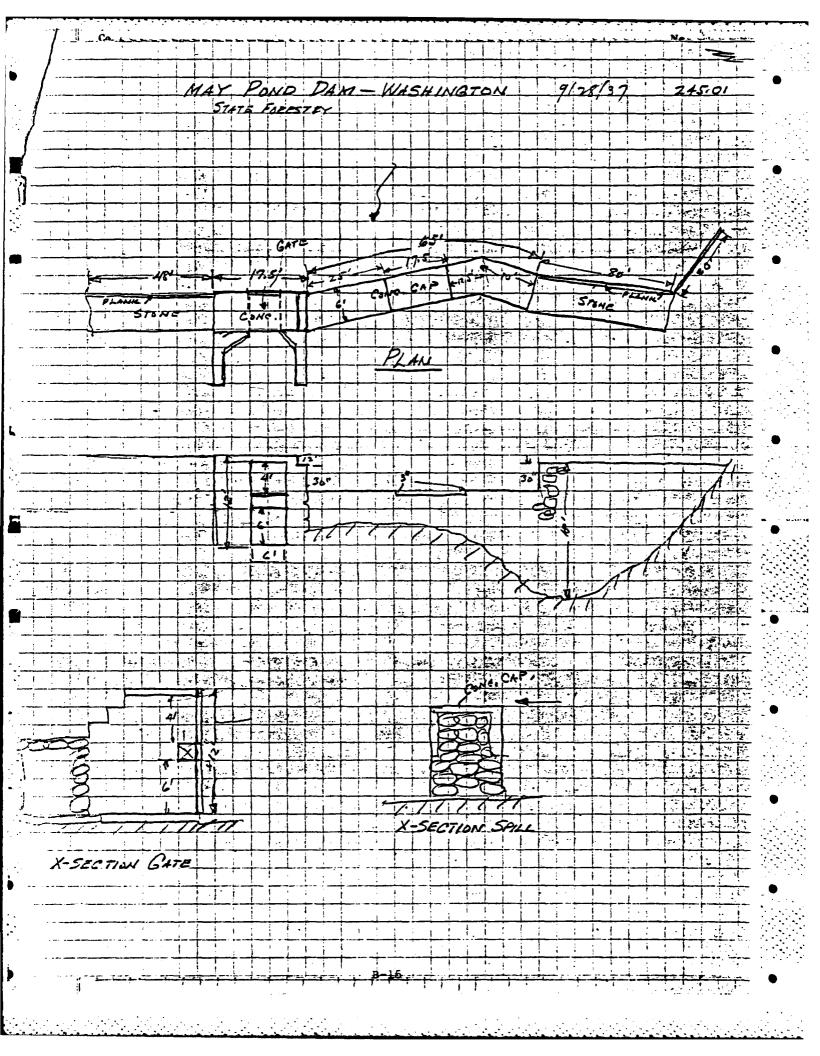
# NEW HAMPSHIRE WATER CONTROL COMMISSION DATA ON DAMS IN NEW HAMPSHIRE

LOCATION			STATE NO245.	
Town	Washington /	: County	Washington /	***************************************
			***************************************	
Basin-Primary	Conn. R. /	: Secondary	Ashuelot R./	•••••••••••••••••••••••••••••••••••••••
		-	***************************************	
GENERAL DATA				
Drainage area:	ControlledSq. M	ii.: Uncontrolled		<u>)1. Sq. Mi.</u>
Overall length o	f dam225ft.: Date	of Construction	rebuilt 1934 🗸	**************
Height: Stream	bed to highest elev18	ft.: Max. Struc	ture 15.5. 15.25	ft
Cost—Dam		: Reservoir	***************************************	***************************************
DESCRIPTION R	ockfill-Concrete ca	ap spillway, st	one&timber 🗸	
Waste Gates				
Туре	.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	concrete 🗸	············	******************
			6 /	
Elevation Inve	ert 8.5	: Total Area	<u> 36 · </u>	sq. ft.
Hoist		<del></del>	***************************************	*****
Waste Gates Co				
Number	: Ma	aterials		**************
Size	ft.: Length	ft.: Area		sq. ft.
Embankment				
Туре	, noora de grande de contraction de contraction de contraction de contraction de contraction de contraction de		*************************************	*****************
Height—Max	, ,	ft.: Min	***************************************	ft.
Top-Width	***************************************	: Elev	***************************************	ft.
Slopes-Upst	ream on		am on	
Length—Righ	nt of Spillway	: Left of Sp	oillway	
Spillway		-		
Materials of	ConstructionCO	ncrete cap	***************************************	***************************************
Length-Tota	1 47.5'high 1	7.5 10#.: Net	15.25	ft.
Height of pe	rmanent section-Max	15.5ft.: Min	15.25	ft.
Flashboards-	-Type	~~~~	: Height	ft.
Elevation—P	ermanent Crest		Top of Flashboard	***********
Flood Capaci	ity	cfs.:	cfs/sq. mi	•
Abutments				
Materials:				******************
Freeboard: 1	Max2.75	ft.: Min	2.5 ′	ft.
	Power Devel(See "Dat			
OWNER	.H. Forestry Reserv	ation /		***************************************
REMARKS Add	itional spillway o	ver gate 6'wid	ie, same elevation./	
Cabulation Pr	RLT	B-13. Data	9/22/39	

# NEW HAMPSHIRE WATER RESOURCES BOARD

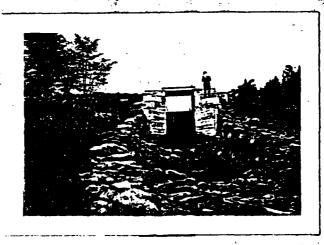
# INVENTORY OF DAMS AND WATER POWER DEVELOPMENTS

DAM			•		-	•	e jest tig
BASIN	Connect	10.15	No.	24	5.01		
	MAY POU			FROM MOUT	H	D.A.SQ.M	1 6.01
TCWN	WAShin	a tore		N. H. Forest			
LOCAL NAME	OF DAM	010		eld Mill	1	· · · · · · · · · · · · · · · · · · ·	
BUILT / 14	34 DEST	RIPTION -		whilestre	Deer Com	27047 731	estructo
		a landatia		Rock fel	1- Conery	ote capse	MAN
	<del></del>	7	• •	Sto	ne, trius	ser teon	creté
POND AREA-	ACRES 102.	SPA DRAV	'IDO''IN FT			PACITY-A	
		OF STREAM-		MAX.		MIN	
OVERALL LE	NGTH OF I	AM-FT - 22	MAX.F	LOOD HEIGH		CREST-F	T
PERMANENT	CREST ELF	ev.u.s. <u>G.S</u>	•	LOCAL			
TAILWATER	ELF	ev.u.s.g.s	• · ·	LOCAL			
SPILLWAY I	Engths-Fi	. 47.5h	16 17.5 10	FREEBO	ARD-FT.	2.5 and	2.75
FLASHBOARD	S-TYPE, H	EIGHT ABOV	e crest_				
WASTE GATE	S-NO. WII	TH MAX OP		PTH SILL B	ELOW CR	EST	
•		6		3.5			
		<del></del>	<u> </u>				1 2
		PUMA	Je 90	nd Dau	1 125	400 in re	Boilt
Prishab			<u> </u>				
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POWER DEVE	RATED		F.S. L GATE	Co ordinat		, 72° 7.	2/3/
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ritaina <del>n</del>		***	<del></del> ,		<del></del>	<del></del>	
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USE Once	POWER	Fan Hill	1 12010/	recned	FIRE		
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	· 0- · ·						
REMARKS ,	Addition	Al Spillwa	VAVer	oate bu	ride. s	ame ale	ration
PSC 50			,	7	•		
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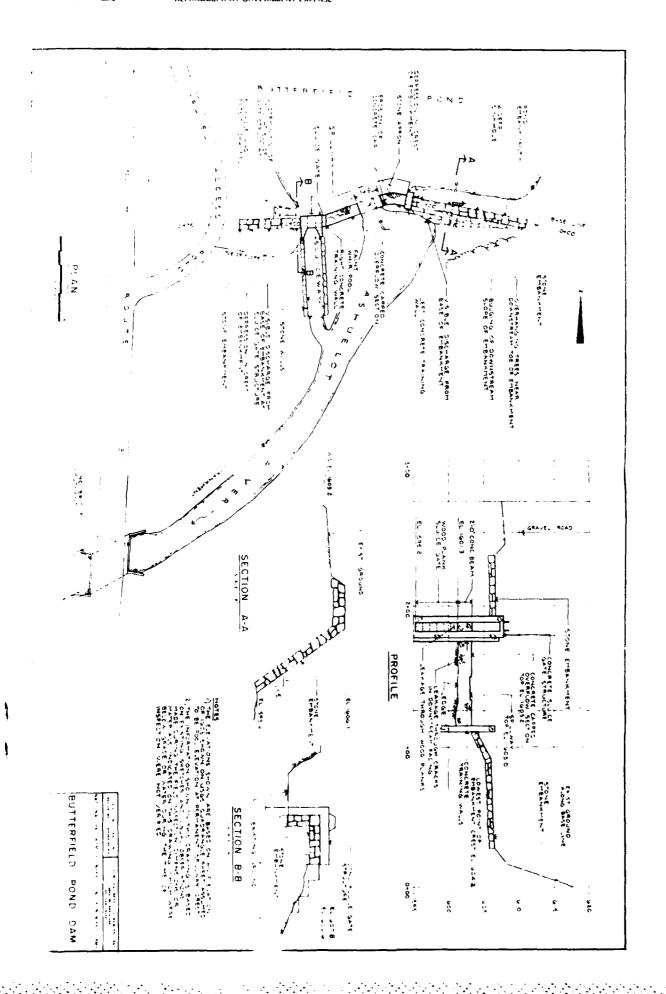
MAY POND IN WASHINGTON
N. H. Forestry Dept.
September 28,1937





Gate

PLANS AND DETAILS



APPENDIX C
SELECTED PHOTOGRAPHS

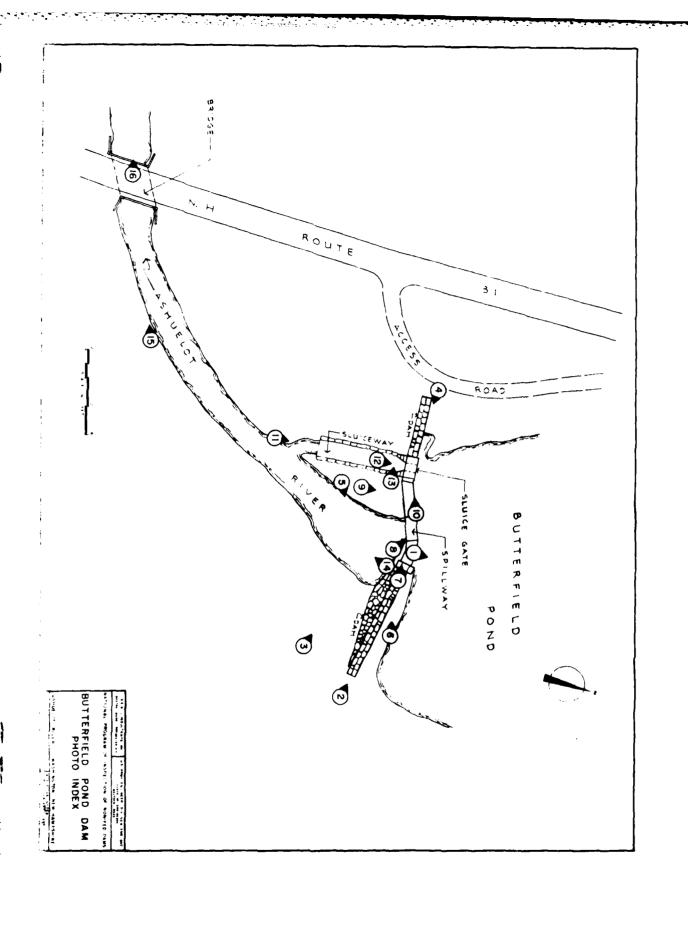






Photo No. 1 - General view of reservoir from dam.



Photo No. 2 - View of crest of dam from left abutment looking toward right abutment



Photo No. 5 - View of downstream face of left stone embankment (Note depression in crest of embankment)



Photo No. 6 - Closeup view of 4 feet deep sink hole located to left of overflow section



Photo No. 9 - Closeup of seepage and cracks on downstream face of overflow section.

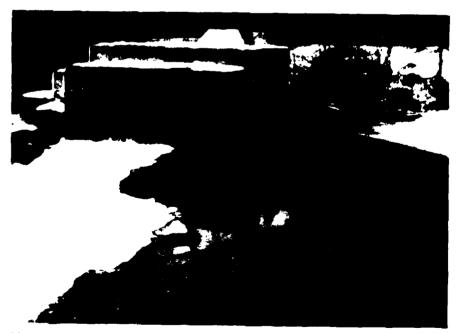


Photo No. 10 - View of upstream face of sluice gate structure and erosion of concrete cap of overflow section.



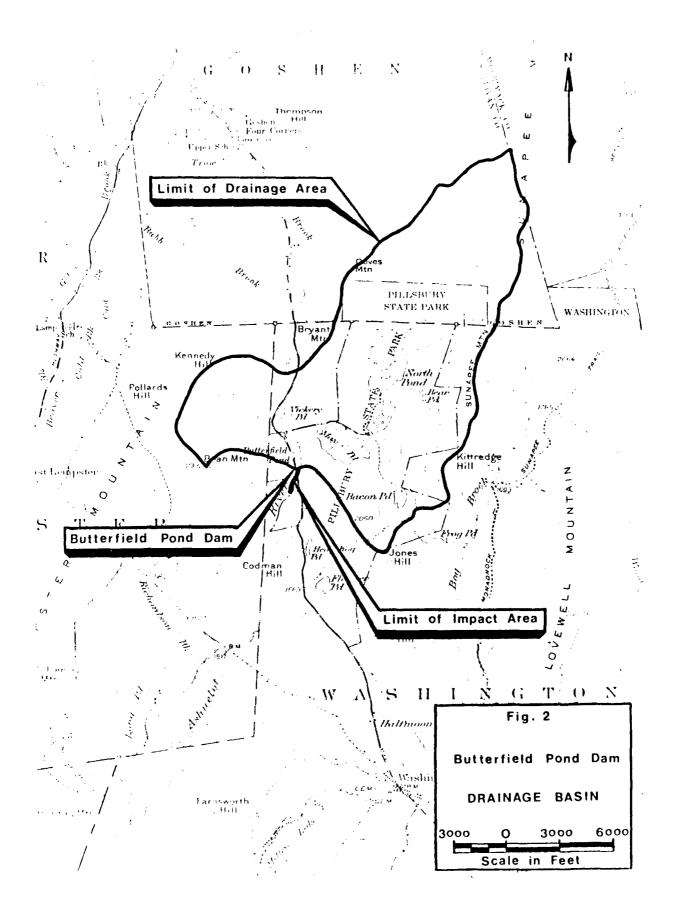
Photo No. 13 - Closeup view of seepage at the downstream end of the right training wall of the sluice gate structure.



Photo No. 14 - General view of downstream channel immediately below dam.

# APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS



SIEIA CONSULTANTS INC.

ENGINEERS / PLANNERS

BOSTON , MASS. ROCHESTER, N.H.

PROJECT Patterned - 1

JOB NO. 274-7901 PAGE 1 04 -7 COMPTO. BY BUP DATE 2/4/80

DETAIL HU trologic Calcs CK'D. By KINS DATE 2/3/30

# I. Basic Data

A. Drainage Area

- 1. 7.15 square miles as diffined on U.S.G.S. sheets and can planmetered
- 2. drainage area would classify as nountainous for estimating MPF Peak Flow Rates

B. Dan and Storage Internation

1. Size Classification: SMALL on Storage ( > 1000 acreft and > 50 acre-ft)

> as indicated toelow storage at crest of lan estimated to be 500 scre-ft

2 Hazard Potential: CIGNIFICANT

Failure could result in lamage to take bridge and highway (N.H. Pouts 31)

# 3. Storage Information

Descriptive Information	Elevation* (feet)	Turrece * Area ainer,	Smorage (me-f-)
1620' contour	1620	25 <i>5</i>	
Test Flood	. 6 0 9 . 5	175	.4.15
Top of left emponement	1606.6	152	935
Top of dam ( Row point a left stend im ordenant)	1604.2	134	530
Normal Fool	1603.2	126	465
Spullway wer crest	1603.0	125	440

ROCHESTER, N.H.

CLIENT AFMY COTOS DETAIL Hydrologic Gas.

JOB NO. 274-7901 PAGE - 0++-PROJECT BUTTE FOLD POND COMPTO. BY PUP DATE -14190 

Notes: (1) elevations: NGVD

- (2) normal pool taken to correspond with sool show on U.Sis sunt, elevation of overflow spillway war crest equal to 1603.0 feet (NGVD)
- (3.) surface area it crest or ism determined by interpolating Ellien the surface areas defred by the post sum on the U.SES suit and the 1620 feet continue
  - (4) Storage at civilinay weir crest e.t. miled by dividing reservoir into Duramical frustrum sections and determine -me volume of each section with the equation for is rolume of a juramilal frustrum.

## C. Spillway Information

1. Overflow section located near the center of -dum was a concrete cap. Adjusted to the right training Wall is a succepte. The fute 15 instructed of wooden plantes in issued in a pormed concrete struture. The gate is presently in operable, and leaks can derably.

> a for the subsequent calculations of Exiliar capacity it was assumed that he simulto was blosed and not leavery.

2 Discharge over the speckway given by croad-crested wer formula

Q = CL H 3/2 (Grantand Handswork 100 CF; Mart)

Q = the thange, city C:6 wrine:

DETAIL Hydrologic Calcs

BOSTON, MASS. Rochester, N.H.

PROJECT - Her told Ford

L = weer length, feet H = head over weir, feet

Il Estimate Effect of Surcharge Storage on Maximum Probable Discharge.

A. Develop Stage-discharge curve for outflow from damcomplex

1. define sources of outflow

a. disclarge over spilling + overflow structure - above elevation 1603.0- as defined above

6. discharge through opening above shuregate - above elevation 1603.3

(1) use broad-crested weir equation rom sécuation 1603.3 to elevation 1607.3. with C=2.6

(2) above elevation 1607.3 flow defined by discharge through an orifice

Q = Ca VZgh (Stanlind Found com - CE's Men =

where Q = discharge, cfs

C = coeff of discharge use 0.6

a = area of orifice, sq. ff

g = acceleration his to a rawing

32.2 ft/sec²

h = head on horizontal counter

line s = r -ree, feet

C. discharge over stone embourement adjust to left abutment alore elevation 16:1.2 1 in user crost-crested where equation as is much above with C = 2.6

BOSTON, MASS.

PROJECT B. He trologic Calcs.

JOB NO. 274-7901 PAGE 4 of -77

COMPTO. BY BWP DATE 2/4/30

DETAIL Hu trologic Calcs.

CK'D. BY YMS DATE 27/32

- d. discharge over right stone embankment above elevation 1606.5
  - (1) use broad-crested werr equation as its inext above with C= 2.6
- e. disclarge over abutments and concrete shuceway
  Structure above elevation 1606. 6
  (1) use broad-crested weir equation as defined above with C=2.6

  f. disclarge over gravel road above elevation 1607. 9

  (1) use broad-crested weir equation with C=2.6

# 2. Discharge over spillway + overflow structure

Elevation (feet NGUD)	С	L (feet)	H (feet)	(د <del>اء</del> )
1603.0			0	0
1604.0	2.6	57	ave ≈ 0.95	137
1605.0		l	1.95	404
1606.0			2.95	751
1607.0			3.95	1160
1609.0			4.95	1630
1609.0			5.95	2150
1610.0			6.95	2720
1611.0			7.95	3320
1612.0			8.95	5170
1613.0	₩	<b>†</b>	9.95	+650

3 Discharge through opening above Sluicegate a between elevations 1603.27' and 1607.27'

Elevation (feet NGVD)	C	L (Leat)	H (iest)	) (4)
1603.27	-		0	5
1604.0	2.6	6.1	0.73	10
1605.0	}		1.73	35
1606.0			2.73	72
1607.0	▼	•	3.73	114

BOSTON, MASS.

PROJECT BITTE Field Pont.

DETAIL Hy thrologic Calcs.

JOB NO. <u>274-7701</u> PAGE 5 01 17 COMPTO. BY <u>Bωρ</u> DATE <u>2/4/30</u> CK'D. BY <u>KMS</u> DATE <u>7 3 30</u>

b. above elevation 1607.27

Elevation (feat NGVD)	С	a (f+z)	h (fea+)	(c+s)
1608.0	0.6	24.4	2.73 3.73	194
1610.0			4.73	256 231
16 12.0	<b>↓</b>		6.73	305 327

4. disclarge over left stone embankment

a. triangular	x-section		· · · · · · · · · · · · · · · · · · ·	<del></del>
Elevation (feet NGVD)	C	(leet)	H, are	(دنع)
1604.17			0	0
1605.0	2.6	9	0.42	6
1606.0	1	13	0.92	<del>-1</del> i
1607.0			1.92	125
1609.0			2.92	234
609.0			3.92	3 53
1610.0		]	4.92	511
1611.0			5.92	<del>े 14</del>
1612.0			6.9Z	352
16 13.0	•	₩	7.92	1040

b. remainder of left stone embankment

Elevation (feet NGVD)	С	L (Leat)	H, sur, (-est)	<u>ن ج</u> ي
1606.08			S	
16070	2.6	63	3.75	5
1608.0	ſ	74	1.75	4.
1609.0		76	2,75	401
1610.0	<b>4</b>	76	5.75	.470

BOSTON, MASS.

PROJECT Bitton Cons

PROJECT Bitton Leld Fond

DETAIL Hydrologic Calcs.

JOB NO. 274-7901 PAGE 6 5 - 7

COMPTO. BY CUP DATE 2/4:80

CK'D. BY KMS DATE 2/3/3/

biremainder of left stone embandement

Fleintim ( (feet NGVD)	C	L (teet)	H (Feek)	ب ر د~ <b>=</b> ر
1611.0	2.6	80	4.75	2150
1612.0	}	9z	5.75	2940
1613.0	₩	84	6.75	3 <i>33</i> 3
			i	

### 5. discharge over right stone ambankment

Elevation	C		H ,	Q
(feet NGUD),		(feet)	(test)	(:45)
1606.43			3	3
1607.0	2.6	46	C.47	39
1609.0	ł	51	1.47	236
1609.0	j		2.47	515
1610.0			3.47	357
1611.0			4.47	1250
1612.0			5.47	1700
1613.0	7	▼	6.47	2180

#### 6. discharge over left training wall & sluice gate structure

a lest train	ning Wall			
Elevation	C	<u></u>	H	Q
(feet NGUD)		(ieed)	(reet)	(c-s)
1606.58	-		)	)
1607.0	2.6	4	0.42	3
1608.0			1.42	13
1609.0			7.42	24
1610.0			3.43	و و و
1611.0			4.42	47
1612.0			5.42	131
1613.0	<b>†</b>	4	6.42	۴٤,

BOSTON , MASS. ROCHESTER, N.H.

PROJECT Butterfield Pond COMPTO. BY BUT DATE DETAIL Hytopiace Cales CK'D. By KINS

214193 

6. shuegate structure

Eleration (feet, NGUD)	C	L (leat)	1 <del>1</del> (Lest)	<u>0</u> (دغی
1607.77	-			0
1608.0	2.6	17.6	0.23	5
1609.0			1.23	2ي
1610.0			2.23	;52
1611.0			3.2 <b>3</b>	266
1612.0			4.23	396
1613.0	₩	4	5.23	547
		1	İ	

7. discharge over growel road to west of right store empaniement

Elevation (feat NGVD).	C	(feet)	H	φ ,,,,,
1607.38			9	0
1609.0	2.6	32	1,87	19
1609.0		35	1.37	146
1610.0	1	39	2.37	नप <i>्</i>
1611.0		42	3,34	576
1612.0		ণহ	4.37	1070
1613.0	1	. 9	<b>5.</b> 87	1590

#### S|E|A CONSULTANTS INC. Engineers / Planners

BOSTON, MASS. ROCHESTER, N.H.

CLIENT Arms Corps

JOB NO. 274-7901 PAGE 3 of 63

PROJECT Citizational Pond

COMPTO. By BWP DATE 2/5/90

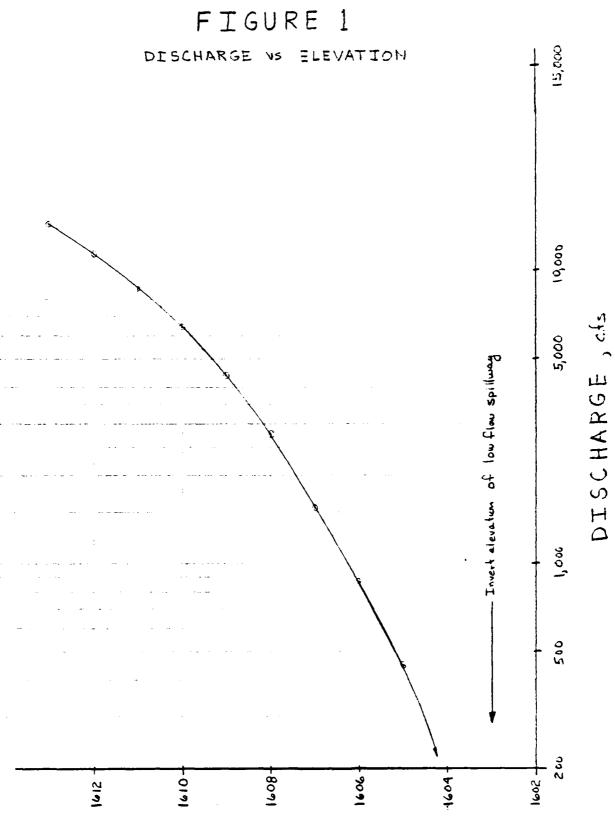
DETAIL Hydrologic Calcs.

CK'D. By 1/1/2 DATE 2/5/1

3. Total discharge from project site

							4
Elevation (feet NGVD	sur emention	LEZNING LEZNING LUGGETA	total left amountment	Promennia.	Company school makers on Single state state	Francy ward	Total
1603.0	0	0	0	0	0	ث	٥
1604.0	137	10	0	0	٥	0	147
1605.0	404	36	6	U	0	ن	446
1606.0	751	72	41	0	0	ي ا	8 64
1607.0	1160	114	240	39	3	0	1560
1608.0	1630	194	679	736	23	19	2790
1609.0	2150	227	1264	5:5	101	146	4400
1610.0	2720	256	1981	957	2:9	CFE	6400
1611.0	3320	231	Z3 Z4	1250	363	576	9710
1612.0	3970	30 <del>5</del>	3792	1700	5.27	1070	11,400
1613.0	4650	327	4370	2180	716	1590	14,300
						i i	
	1	1	1	I	ı		ł

Discharge us Elevation shown graphicality in Francis



E [ E N V LI O N ) test ( N P N D )

BOSTON, MASS. Rochester, N.H.

CLIENT Army Corps	Jos No. <u>274-7901</u>	PAGE 10 0 + 17
PROJECT Butter field Fond Dun	COMPTO. BY PUR	DATE
DETAIL Hydrologic Calcs	Ck'o. By	DATE _ 5 2 3)

- B. Effect of surcharge storage on max. prob. discharge
  - 1. Pertinent Data
    - a. Drainage area = 7.15 square mles
    - b. Characteristics of basin mountaincus
    - c. Test flood = 1/2 PMF (SMALL SIZE 2nd SIGNIFICANT
    - d. Follow Army Corps' procedure
  - 2. STEP 1: Determine Peak Inflow Qp1 from Guide Curve
    - a. the maximum probable discharge was estimated to be 2100 cts /5g m.

- 3. STEP 2: Determine surcharge height to pass  $Q_{P1}$ , STOR<sub>1</sub>, and  $Q_{P2}$ 
  - a. from Figure 1 determine surpharge height to pass  $Q_{\rm Pl}$  = 7,500 cfs

Surcharge elevation = 
$$1600.5'$$
  
21ev. of. overflow spelling weir =  $\frac{1603.0'}{7.5}$  feet

b. determine volume of surcharge STOP, in inches of runoff

> first determine volume so storage raincier in so my mais (1) determine surface area so mont corresponding to surcharge elevation from Fine 2 = 132 cores

(2) surrage surface area for surchange with ...

BOSTON, MASS. ROCHESTER, N.H.

CLIENT Army Corps

JOB No. 274-7301

PAGE 2 of 57

PROJECT Titler + ald Pond

Compto. By BWB

Date 15120

DETAIL Hydrologic Calcs

CK'D. By - MS

Date 215130

(3) multiply surcharge (depth home himstern 1603.5 times overage surface area is determine volume of Storage in acre-til for opit are following equation:

STOR<sub>1</sub> = <u>Volume of storage (as acre-inches</u>)

drainage area

STOR, = 3.02 inches

c. determine Q<sub>P2</sub>

$$Q_{P2} = Q_{P1} \left( 1 - \frac{STOR_1}{9.5''} \right)$$

$$Q_{P2} = \left( 7,500cfs \right) \left( 1 - \frac{3.02''}{9.5''} \right)$$

Q<sub>P2</sub> = 5,120 cfs

- 4. STEP 3: Determine surcharge helicity is a simple of  $Q_{\rm P2}$  and then  $Q_{\rm P3}$ 
  - a. From Figure 1 determine surcharge height to pass  $Q_{\rm P2} = 5,120$  cfs

surface area at 1609.4' = 174 acres

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b. determine STOR<sub>2</sub>

$$STOR_2 = \frac{(1742 + 12524)(6.4 + 1)(.2^{1/2})}{4576 \text{ acres}}$$

$$= 2.51 \text{ inches}$$

c. Average STOR, and STOR,

$$STOR_{AVG} = \frac{STOR_1 + STOR_2}{2}$$

$$STOR_{AVG} = \frac{3.02'' + 2.51''}{2}$$

$$STOR_{AVG} = 2.77 \text{ inches}$$

d. determine Q<sub>P3</sub>

$$Q_{P3} = (7,5\infty cfs)(1 - \frac{2.77"}{9.5"})$$
 $Q_{P3} = 5,320 cfs$ 

- 5. STEP 4: Determine surcharge height for  $Q_{P3}$  and STOR<sub>3</sub>
  - a. from Figure 1 surcharge height for  $Q_{p3} = 5,320$  cms

b. determine STOR<sub>3</sub>

$$STOR_3 = \frac{(175ac + 125ac)(6.5f+)(12''/14)}{4576 \text{ aves}}$$

POCHESTER, N.H.

CLIENT Army Corps DETAIL Hydrologic Calcs

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$$STOR_3 = 2.56$$
 inches

c. determine STOR

$$STOR_{AVG} = \frac{2.77" + 2.56"}{2}$$

d. determine Qpu

$$Q_{p4} = (7,500 \text{ cts}) \left(1 - \frac{2.67}{9.5}\right)$$

$$Q_{p4} = 5,390 \text{ cts}$$

- 6. STEP 5: Determine surcharge height for  $Q_{p_4}$  and  $STOR_{4}$ , and
  - From Figure 1 surcharge height for  $Q_{D_4} = 5.3 \, 90 \, =$

surface area at 1609.5'= 175

b. determine STOR<sub>4</sub> = 
$$\frac{(175ac + 125ac)(6.5f+)(12",14)}{2}$$
STOR<sub>4</sub> = 
$$\frac{(175ac + 125ac)(6.5f+)(12",14)}{2}$$

c. determine STOR<sub>AVG</sub>

$$STOR_{AVG} = \frac{2.67" + 2.56"}{2}$$

= 2.62 incles

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DETAIL Hydrologic Cales CK'D. BY KMS

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d. determine Ops

$$Q_{75} = (7,500 \text{ cts}) \left(1 - \frac{2.62''}{9.5''}\right)$$

Qp= = 5,430 cfs

6. STEP 6: Determine surcharge height for aps and STORS

a. From Figure 1 surcharge height for Ops = 5,430cts

Surcharge height = 1609.5' eler. spillway wer crest = 1603.0 surciarge height = 6.5 feet

Surface area at 1609.5' = 175 acres

b. determine STORS = (175ec + 125ec) (6.5 2) (12 1/1)

STORS = 4,576 acres

STOR5 = 2.56 incles

c. determine STOR AVG

STORAGE = 2.59 inches

STORS and STORAIG agree to what about 1% flactor licent test is usinge = 5,430 cts at surcharge elem = 1609.5 feet

7. In Conclusion

a Test flood discharge = 5,430cts and will overtop Over spillman were crest by 6.5 feet and the dam aest by 5.3 toet

PROJECT Tritter Sid Tout Dom

DETAIL Hydrologic Calcs

b. overflow spellway capacity

(1) water surface at low point on left stone ambunkment - , 504. 2

$$Q = (2.6)(16.2')(1604.2 - 1603.5)^{3/2} + (2.6)(40.3')(1604.2' - 1603.2')^{3/2} = 160cts$$

(2) water surface at top of left abutment - 1606.6

$$Q = (2.6)(16.2')(1606.6' - 1603.0')^{3/2} + (2.6)(40.8')(1606.6' - 1603.2)^{3/2} = \frac{450chs}{1606.6}$$

(3) water surface at test food elevation - 1609.5'

$$Q = (2.6)(16.2')(1609.5' - 1603.0)^{3/2} + (2.6)(40.8')(1609.5 - 1603.2)^{3/2} \approx 2375cf$$

C. slucegate capacity - includes discharge through 6.1' wide by 6.05' high slucegate - crifice discharge

(1) water surface at low point on left stree embankment-1604.2  $(a)Q_{\text{slucecade}} = (0.6)(6.1')(6.05')[(2)(37.7)(604.2'-1598.75)]$   $Q_{\text{slucecade}} = 435 \text{ cls}$ 

(2) water surface at top or let had went - 1606.6 '
(4) Quagete = (0.6)(6.1)(6.05) [(2)(30.2), 1606.6 '- 1613.25].

Georgete ≈ 515 cts

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CLIENT Army Corps	JOB No. 274-7901	PA
PROJECT Butterfield Dand Dan	COMPTO. BY BUP	_ DA
DETAIL	Ck'o. 8y	DA

d capacity of low flow scillway

$$Q = (2.6)(16.2)(0.7)^{3/2} =$$

3.9c/s

BOSTON, MASS. ROCHESTER, N.H.

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- III. Using "Rule of Thumb" Guidance for Estimating Downstream Dam Failure
  Hydrographs examine impact of dam failure
  - 1. Pertinent Data
    - a. Failure occurs when reservoir level at crest of dam elevation = 1604.2
    - b. Storage at crest elevation estimated to be approximately 590 acre-feat
  - A. Reach 1
    - 1. STEP 1: Determine reservoir storage at time of failure

      from previous calcs. storage = 590 and -f+
    - 2. STEP 2: Determine Peak Failure Outflow QP1

$$Q_{P1} = (8/27) W_b \sqrt{g} Y_o^{3/2}$$

 $Y_{o} = \text{Total height from channel bed to pool}$   $\text{level at failure} \qquad |604.2'$   $= |2.2 \text{ feet} \qquad \approx |592.0'|$   $Q_{P1} = (8/27)(84 \text{ feet})(32.2)^{1/2}(12.2 \text{ fe})^{3/2}$   $Q_{P1} \approx 6,000 \text{ cfs}$ 

retailure How is regulate compared to the dam forture the charge and increases a professional conformations

BOSTON , MASS. BOCHESTER, N.H.

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- 3. STEP 3: Prepare stage-discharge curve for Reach /
  - a. Pertinent Data
    - (1) Reach length = 350 feet
    - (2) Channel slope = 0.0155
    - (3) Manning n = 0.05
    - (4) Channel shape trape roulal
    - (5) Base width ≈ 20 feat
  - b. See Figure 3 for stage-discharge curve
- 4. STEP 4: Estimate Reach Outflow
  - a. Determine stage for  $Q_{P_1} = 6000 c$  from Figure 3 and find volume in reach
    - (1) Stage (depth of flow) = 7.6 feet
    - (2) Volume in reach = (reach length) (cross-sectional)

      X-area = (0.5) (7.64+)( 204+1334+)  $= 5814^{2}$

$$X-\text{area} = (0.5) (7.644)(2044)$$

$$= 581 \text{ ft}^{2}$$

$$= (58144^{2}; (350 \text{ ft}^{2}))$$

$$= 4.7 \text{ are - ft}$$

$$v_1 < \frac{s}{2}$$
 : reach length OK

b. Determine Q<sub>P</sub> (TRIAL)

$$Q_{PZ(TRIAL)} = Q_{PI} \left( 1 - \frac{V_1}{5} \right)$$

$$Q_{PZ(TRIAL)} = \left( 6000 \, \text{c}^{\frac{1}{2}} \right) \left( 1 - \frac{4.7 \, \text{ac}^{\frac{1}{2}}}{590 \, \text{ac}^{\frac{1}{2}}} \right)$$

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BOSTON, MASS

PROJECT Butterfield Pont Dam COMPTD. BY BWP

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c. Compute V<sub>2</sub> using Q<sub>P2 (TRIAL)</sub>

From Figure 3 determine stage for  $Q_{P2(TRIAL)}$ 

Stage = 7.5 feet  
X-area = (0.5) (7.5 ft) (20 ft + 132 ft)  
= 570 ft<sup>2</sup>  

$$V_2 = \frac{(570 ft^2)(350 ft)}{43.560 ft^2/kme}$$
  
 $V_2 = 4.6 ame-ft$ 

d. Average  $V_1$  and  $V_2$  and compute  $Q_{\rm P2}$ 

(1) 
$$Vavg = \frac{V_1 + V_2}{2}$$

$$Vavg = \frac{4.7 ac-f+ + 4.6 ac-f+}{Z}$$

(2) 
$$Q_{PZ} = Q_{P1} \left(1 - \frac{Vavg}{S}\right)$$

$$Q_{PZ} = \left(6000cts\right) \left(1 - \frac{4.7}{590}\right)$$

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PROJECT Survey Part Dam COMPTO. BY BWP DATE 2/5/90

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#### 3. Reach 2

- 3. STEP 3: Prepare stage-discharge curve for Reach 2
  - a. Pertinent Data
    - (1) Reach length = 175 feet
    - (2) Channel slope = 0.0375
    - (.3) Manning n = 0.05
    - (4) Channel shape trapezoulis
    - (5) Base width ≈ 20 feet
  - b. See Figure 3 for stage-discharge curve
- 4. STEP : Estimate Reach Outflow
  - a. Determine stage for  $Q_{P2} = 5950$  cts from Figure 3 and find volume in reach
    - (1) Stage (depth of flow) = 6.3 feet
    - (2) Volume in reach = (reach length) (cross-sectional) area of channel)

$$X-area = (0.5)(6.3f.)(20.4 + 115.4.)$$
  
 $\approx 425 \text{ ft}^2$ 

Volume = 
$$V_1 = \frac{(425 \text{ ft}^2)(175 \text{ ft})}{43,560 \text{ ft}^2/\text{acre}}$$
  
= 1.7 ac-ft

$$v_1 < \frac{S}{2}$$
 : reach length OK

b. Determine Q<sub>PS(TRIAL)</sub>

$$Q_{p^{2}(TRIAL)} = Q_{p_{2}} \left(1 - \frac{V_{1}}{3}\right)$$

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PROJECT BUTTE TELL Pond Dam COMPTO BY BWP DATE 2/5/80

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c. Compute V<sub>2</sub> using Q<sub>PS</sub>(TRIAL)

From Figure 3 determine stage for  $Q_{\rm P}$  (TRIAL)

Stage = 6.3 feet  
X-area = (0.5)(6.3f+)(20f+ + 115++)  

$$\approx 425 \text{ f+}^2$$
  
 $V_2 = \frac{(425 \text{ f+}^2)(175 \text{ f+})}{43,560 \text{ f+}^2/\text{kcre}}$   
 $V_2 = 1.7 \text{ acre-f+}$ 

d. Average  $V_1$  and  $V_2$  and compare 2.3

(1) 
$$Vavg = \frac{V_1 + V_2}{2}$$
  
 $Vavg = \frac{1.7 \text{ ac-f+} + 1.7 \text{ ac-f+}}{2}$ 

$$(2) \quad Q_{P3} = Q_{P2} \left(1 - \frac{Vavg}{S}\right)$$

$$Q_{P3} = (5,950cts)(1-\frac{1.7}{590})$$

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#### C. Reach 3

- 3. STEP 3: Prepare stage-discharge curve for Reach 3
  - a. Pertinent Data
    - (1) Reach length = 725 feet
    - (2) Channel slope = O.O27G
    - (.3) Manning n = 0.05
    - (4) Channel shape trape zoidal
    - (5) Base width ≈ 20 feet
  - b. See Figure 3 for stage-discharge curve
- 4. STEP4: Estimate Reach Outflow
  - a. Determine stage for  $Q_{P3} = 5,930$  cts from Figure 3 and find volume in reach
    - (1) Stage (depth of flow) = 6.8 feet
    - (2) Volume in reach = (reach length) (cross-sectional) area of channel)

$$X-\text{area} = (0.5)(6.8.-)(20.- + 122ft)$$

$$\approx 483 ft^{2}$$

$$\text{Volume} = V_{1} = \frac{(483 ft^{2})(25 ft)}{42.560 ft^{2}/\text{acre}}$$

$$= 8.0 \text{ acre-} ft$$

$$v_1 < \frac{S}{2}$$
 ... reach length OK

b. Determine Q<sub>P4(TRIAL)</sub>

$$Q_{P4(TRIAL)} = Q_{P3} \left( 1 - \frac{V_1}{5} \right)$$

$$Q_{P4(TRIAL)} = \left( 5.930 \text{ cis} \right) \left( 1 - \frac{9.0}{590} \right)$$

$$Q_{P4(TRIAL)} = 5.850 \text{ cfs}$$

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c. Compute V<sub>2</sub> using Q<sub>P</sub>4(TRIAL)

From Figure 3 determine stage for  $Q_{\text{Pd}}(\text{TRIAL})$ 

Stage = 6.8 feet

X-area = 
$$(0.5)(6.8f+)(20f+ + 122f+)$$
 $\approx 483f+^2$ 
 $V_2 = \frac{(483f+^2)(725f+)}{43,560f+^2/acre}$ 
 $V_2 = 8.0$  size -  $f+$ 

d. Average  ${\rm V_1}$  and  ${\rm V_2}$  and compared

(1) 
$$Vavg = \frac{V_1 + V_2}{2}$$

$$Vavg = \frac{8.0 \text{ sere-fr} + 8.0 \text{ sere-fr}}{2}$$

(2) 
$$Q_{P4} = Q_{P3} \left(1 - \frac{Vavg}{S}\right)$$

BOSTON, MASS.

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D. Reach 4

- 3. STEP 3: Prepare stage-discharge curve for Reach 4
  - a. Pertinent Data
    - (1) Reach length = 1650 feet
    - (2) Channel slope = 0.0077
    - (3) Manning n = 0.05
    - (4) Channel shape trapezoidal
    - (5) Base width ≈ 20 feet
  - b. See Figure 3 for stage-discharge curve
- 4. <u>STEP4</u>: Estimate Reach Outflow
  - a. Determine stage for  $Q_{p4} = 5.850c$  from Figure 3 and find volume in reach
    - (1) Stage (depth of flow) = 4.4 feet
    - (2) Volume in reach = (reach length) (cross-sectional)

      X-area = (0.5)(4.4 f+)(20 f+ + 530)=  $1320 \text{ f}+^2$ Volume =  $V_1 = \frac{(1320 \text{ f}+^2)(1650 \text{ f}+^2)}{43,560 \text{ f}+^2/acc}$

$$v_1 < \frac{s}{2}$$
 ... reach length OK

b. Determine Qp5(TRIAL)

$$Q_{P5(TRIAL)} = Q_{P4} \left(1 - \frac{\gamma_1}{3}\right)$$

$$Q_{PS(TF,AL)} = (5,850 \pm 5,(1 - \frac{50}{590})$$

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Compute V<sub>2</sub> using Q<sub>P</sub>5(TRIAL)

From Figure 3 determine stage for \$r5(TRIAL)

Stage = 
$$4.2 \pm ext$$
  
X-area =  $(0.5)(4.2 + )(20 + + 554 + )$   
 $\approx |205 + 2|$   
 $V_2 = \frac{(1205 + 2)(1650 + 2)}{43,560 + 2}$   
 $V_2 = 45.7 \text{ acre-} + 1$ 

d. Average  $V_1$  and  $V_2$  and compare 7 5

(1) 
$$Vavg = \frac{V_1 + V_2}{2}$$

$$Vavg = \frac{50.0 ac-f+ + 45.7 ac-it}{2}$$

(2) 
$$Q_{ps} = Q_{pq} \left(1 - \frac{Vavg}{S}\right)$$

$$Q_{P5} = (5,950 \text{ cts}) (1 - \frac{47.9}{590})$$

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E. Reach 5

- 3. STEP3: Prepare stage-discharge curve for Reach 5
  - a. Pertinent Data
    - (1) Reach length = 950 feet
    - (2) Channel slope = 0.0077
    - (3) Manning n = 0.05
    - (4) Channel shape trapezoilal
    - (5) Base width  $\approx 20 \text{ fee}$
  - b. See Figure 3 for stage-discharge curve
- 4. STEP☆: Estimate Reach Outflow
  - a. Determine stage for  $Q_{pg} = 5.330$  c/s from Figure ? and find volume in reach
    - (1) Stage (je; th of flow) = 6.8 feet
    - (2) Volume in reach = (reach length) (aross-sectional)

      X-area = (0.5)(6.8 1)(20 + 234 + 234 + 234)  $\approx 864 + 236 +$

$$x-area = (0.5)(6.8 - art)(-3 - art)$$

$$\approx 364 - art$$

$$volume = v_1 = \frac{(864 + art)(953 - art)}{43.560 - art/arre}$$

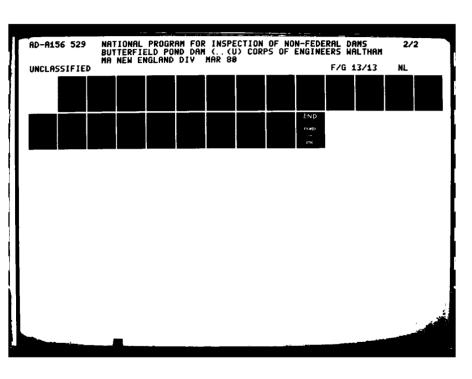
$$= 18.8 ase - art$$

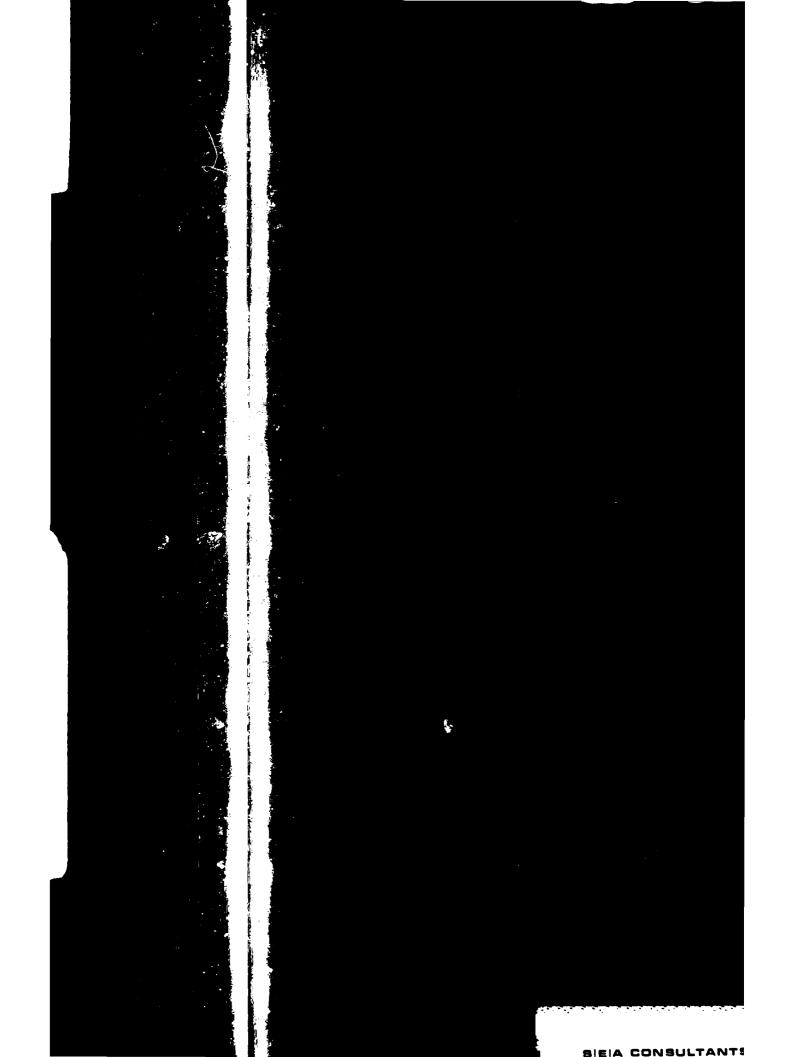
$$v_1 < \frac{s}{2}$$
 . reach length 3K

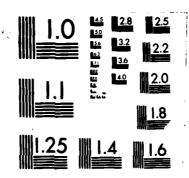
b. Determine P6 (TRIAL)

$$Q_{PS}(TRIAL) = Q_{PS}\left(1 - \frac{7}{2}\right)$$

$$^{3}$$
 =  $(5,380c^{-1})(1-\frac{19.3}{590})$ 







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c. Compute V<sub>2</sub> using Q<sub>PG</sub>(TRIAL)

From Figure 3 determine stage for  $Q_{\rm P}$  (TRIAL)

Stage = 6.7 feet

X-area = (0.5)(6.7 feet)(20 feet + 230 feet)

$$\approx 838 \text{ f+}^2$$
 $V_2 = \frac{(838 \text{ f+}^2)(950 \text{ f+})}{43.560 \text{ f+}^2/\text{acre}}$ 
 $V_2 = 18.3 \text{ Gere-f+}$ 

d. Average  $V_1$  and  $V_2$  and compute  $2\cdot \zeta$ 

(1) 
$$Vavg = \frac{V_1 + V_2}{2}$$

$$Vavg = \frac{18.8 \text{ and } -f+ + 18.3 \text{ acce-} f+}{2}$$

(2) 
$$Q_{PG} = Q_{PS} \left(1 - \frac{Vavg}{S}\right)$$

$$Q_{P6} = (5,380 \text{ cfs}) (1 - \frac{18.5}{590})$$

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#### F. Reach 6

- 3. STEP3: Prepare stage-discharge curve for Reach &
  - a. Pertinent Data
    - (1) Reach length = 1550 feet
    - (2) Channel slope = 0.00457
    - (3) Manning n = 0.05
    - (4) Channel shape trape zoidal
    - (5) Base width ≈ 20 feet
  - b. See Figure 3 for stage-discharge curve
- 4. STEP4: Estimate Reach Outflow
  - a. Determine stage for  $Q_{P6} = 5,210$  Cfs from Figure 3 and find volume in reach
    - (1) Stage (depth of flow) = 7.5 Feet
    - (2) Volume in reach = (reach length) (cross-sectional) area of thinnel)

      X-area = (0.5)(7.5 Leat)(20 Leat + 255 Leat)=  $1031 \text{ ft}^2$ Volume =  $V_1 = \frac{(1031 \text{ ft}^2)(1550^{-1})}{43,560 \text{ ft}^2/\text{acre}}$ = 36.7 acre-ft

 $v_1 < \frac{S}{2}$  ... reach length OK

b. Determine Q<sub>P7(TRIAL)</sub>

$$Q_{P7(TRIAL)} = Q_{P6} \left( 1 - \frac{V_1}{S} \right)$$

$$Q_{P7(TRIAL)} = \left( 5,210 \text{ cfs} \right) \left( 1 - \frac{36.7}{590} \right)$$

$$Q_{P7(TRIAL)} = 4,890 \text{ cfs}$$

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c. Compute V<sub>2</sub> using Q<sub>P7</sub>(TRIAL)

From Figure 3 determine stage for QP7(TRIAL)

Stage = 7.3 feet  
X-area = (0.5) (7.3 feet) (20 ft + 249 ft)  

$$\approx 982 \text{ C+2}$$
  
 $V_2 = \frac{(982 \text{ ft}^2) (1550 \text{ ft})}{43,560 \text{ ft}^2/\text{acre}}$   
 $V_2 = 34.9 \text{ acre-ft}$ 

d. Average  ${\rm V_1}$  and  ${\rm V_2}$  and compute 1.7

(1) 
$$Vavg = \frac{V_1 + V_2}{?}$$

$$Vavg = \frac{36.7 \text{ ac-ft}}{2}$$

(2) 
$$Q_{pq} = 0 - 6 \left(1 - \frac{\text{Vavg}}{9}\right)$$

$$Q_{pq} = \left(5,210 \text{ its}\right) \left(1 - \frac{35.9}{590}\right)$$

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6 Read 7

- 3. STEP 3: Prepare stage-discharge curve for Reach 7
  - a. Pertinent Data
    - (1) Reach length = Z8Z5 feet
    - (2) Channel slope = 0.00457
    - (.3) Manning n = 0.05
    - (4) Channel shape trape = oidal
    - (5) Base width ≈ 20 feet
  - b. See Figure 3 for stage-discharge curve
- 4. STEP 4: Estimate Reach Outflow
  - a. Determine stage for  $Q_{p,7} = 4.890cHs$  from Figure 3 and find volume in reach
    - (1) Stage (depth of flow) = 7.4 feet
    - (2) Volume in reach = (reach length) (cross-sectional)

$$X-\text{area} = (0.5)(7.4 \text{ feat})(204 + 24544)$$

$$= 981 \text{ ft}^{2}$$

$$Volume = V_{1} = \frac{(981 \text{ ft}^{2})(292544)}{43,560 \text{ ft}^{2}/\text{acre}}$$

$$v_1 < \frac{S}{2}$$
 : reach length OK

b. Determine Qps(TRIAL)

$$Q_{P8(TRIAL)} = Q_{P7} \left(1 - \frac{V_1}{S}\right)$$

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PROJECT Externel Fond Dom Compto. By BWF DATE 2/6/90

DETAIL Hydrologic Calcs. CK'D. By 32 DATE 3/6/90

c. Compute V<sub>2</sub> using Q<sub>P8(TRIAL)</sub>

From Figure 3 determine stage for Qpe(TRIAL)

Stage = 7.0 feat  
X-area = (0.5)(7.0 -eat)(20 ft + 232 ft)  
= 882 ft<sup>2</sup>  

$$V_2 = \frac{(882ft^2)(2825ft)}{43,560 ft^2/acre}$$
  
 $V_2 = 57.2 acre-ft$ 

d. Average  $V_1$  and  $V_2$  and compute 0.8

(1) 
$$Vavg = \frac{V_1 + V_2}{2}$$

$$Vavg = \frac{63.6 \text{ ac-f+} + 57.2 \text{ ac-f+}}{2}$$

(2) 
$$Q_{PB} = Q_{PT} \left(1 - \frac{Vavg}{S}\right)$$

$$Q_{PS} = (4,890 \text{ cts}) \left(1 - \frac{60.4}{590}\right)$$

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H. Read 8

- 3. STEP 3: Prepare stage-discharge curve for Reach 3
  - a. Pertinent Data
    - (1) Reach length = 5625 feet
    - (2) Channel slope = 0.00356
    - (.3) Manning n = 0.05
    - (4) Channel shape trapezoidas
    - (5) Base width ≈ 20 feet
  - b. See Figure 3 for stage-discharge curve
- 4. STEP 4: Estimate Reach Outflow
  - a. Determine stage for Qp8 = 4,390 c+3 from Figure 3 and find volume in reach
    - (1) Stage (depth of flow) = 6.1 feet
    - (2) Volume in reach = (reach length) (cross-sectional) area of channel)

$$X-\text{area} = (0.5)(6.1 \text{ feet})(20 \text{ feet} + 355)$$

$$= 1(44 \text{ ft}^2)$$

$$\text{Volume} = V_1 = \frac{(1(44 \text{ ft}^2))(5625 \text{ ft}^2)}{43.5625 \text{ ft}^2/3666}$$

$$v_1 < \frac{S}{2}$$
 : reach length OK

b. Determine Qpq(TRIAL)

$$Q_{Pq(TRIAL)} = Q_{PS} \left( 1 - \frac{V_1}{S} \right)$$

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c. Compute V<sub>2</sub> using Q<sub>P9(TRIAL)</sub>

From Figure 3 determine stage for Qp9(TRIAL)

Stage = 5.4 feet  
X-area = 
$$(0.5)(5.4 \text{ feet})(20 \text{ feet} + 318 \text{ ft})$$
  
= 913 ft<sup>2</sup>  
 $V_2 = \frac{(913 + 2)(5625 \text{ ft})}{43,560 \text{ ft}^2/acre}$   
 $V_3 = 118 \text{ acre-ft}$ 

d. Average  $\mathbf{V_1}$  and  $\mathbf{V_2}$  and compute  $\mathbf{Q_{pq}}$ 

(1) 
$$Vavg = \frac{V_1 + V_2}{2}$$

$$Vavg = \frac{149ae-f+ + 119ac-f+}{Z}$$

(2) 
$$Q_{pq} = Q_{pg} \left(1 - \frac{Vavg}{3}\right)$$

$$Q_{pq} = (4,390 \text{ c/s}) (1 - \frac{133}{590})$$

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- 3. STEP 3: Prepare stage-discharge curve for Reach >
  - a. Pertinent Data
    - (1) Reach length = 2875 feet
    - (2) Channel slope = ○. 139
    - (3) Manning n = 0.08
    - (4) Channel shape trapezoidal
    - (5) Base width ≈ 40 feet
  - b. See Figure 3 for stage-discharge curve
- 4. STEP 4: Estimate Reach Outflow
  - a. Determine stage for  $Q_{pq} = 3,400 c$  from Figure 3 and find volume in reach
    - (1) Stage (depth of flow) = 5.5 feet
    - (2) Volume in reach = (reach length) (cross-sectional) area of channel)

$$\begin{aligned} & \cdot \text{X-area} &= (0.5)(5.5 \text{ feet})(404 + 72044) \\ &= 2090 \text{ ft}^2 \end{aligned}$$

$$\begin{aligned} &\text{Volume} &= V_1 &= \frac{(2090 \text{ ft}^2)(2875 \text{ ft})}{43,560 \text{ ft}^2/\text{acre}} \\ &= 138 \text{ acre-ft} \end{aligned}$$

$$v_1 < \frac{S}{2}$$
 : reach length OK

b. Determine QPio(TRIAL)

$$Q_{PiO(TRIAL)} = Q_{Pq} \left( 1 - \frac{V_1}{S} \right)$$

$$Q_{P/O(TRIAL)} = (3,400 cts) (1 - \frac{138}{590})$$

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c. Compute V<sub>2</sub> using Q<sub>Plo(TRIAL)</sub>

From Figure 3 determine stage for QPIX(TRIAL)

Stage = 4.9 feet  
x-area = (0.5)(4.9 ft)(40 ft + 600 ft)  
1568 ft<sup>2</sup>  

$$V_2 = \frac{(1568 ft^2)(2875 ft)}{43.560 ft^2/ane}$$
  
 $V_2 = 103 acre-ft$ 

d. Average  $V_1$  and  $V_2$  and compute  $Q_P$ 

(1) 
$$Vavg = \frac{V_1 + V_2}{2}$$

$$Vavg = \frac{138 ac + 103 ac + 1}{2}$$

(2) 
$$Q_{P10} = Q_{P9} \left(1 - \frac{Vavg}{5}\right)$$

$$Q_{P10} = \left(3,400 \text{ cts}\right) \left(1 - \frac{121}{590}\right)$$

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J. Reach 10

3. STEP 3: Prepare stage-discharge curve for Reach ! ?

- a. Pertinent Data
  - (1) Reach length = 5,300 feat
  - (2) Channel slope = 0.0011
  - (3) Manning n = 0.08
  - (4) Channel shape trope zoulal
  - (5) Base width = 40 Leut
- b. See Figure 3 for stage-discharge curve
- 4. STEP 4: Estimate Reach Outflow
  - a. Determine stage for  $Q_{Plo} = 2.710 cts$  from Figure 3 and find volume in reach
    - (1) Stage (depth of flow) = 6.7 feat
    - (2) Volume in reach = (reach length) (cross-sectional)

$$X-\text{area} = (0.5) (6.7 \text{ feet}) (404 + 525 \text{ ft})$$

$$= 1893 \text{ ft}^{2}$$

$$\text{Volume} = V_{1} = \frac{(1893 \text{ ft}^{2}) (5.300 \text{ ft})}{43.560 \text{ ft}^{2}/\text{acre}}$$

$$= 230 \text{ acre} - \text{ft}$$

 $v_1 < \frac{s}{2}$  : reach length OK

b. Determine Qpu(TRIAL)

$$Q_{PN(TRIAL)} = Q_{P10} \left( 1 - \frac{V_1}{S} \right)$$

$$Q_{PN(TRIAL)} = \left( 2.710 \text{ cfs} \right) \left( 1 - \frac{230}{590} \right)$$

$$Q_{PN(TRIAL)} = 1,650 \text{ cfs}$$

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c. Compute V<sub>2</sub> using Q<sub>PII(TRIAL)</sub>

From Figure 3 determine stage for  $Q_p$  (TRIAL)

Stage = 5.4 feat  

$$X-area = (0.5)(5.4 feat)(40 + 433 + 1)$$
  
 $= 1277 ft^{2}$   
 $V_{2} = \frac{(1277 ft^{2})(5,300 ft)}{43,560}$   
 $V_{2} = 155 acre-ft$ 

d. Average  ${\rm V_1}$  and  ${\rm V_2}$  and compute  ${\rm C_P}$ 

(1) 
$$Vavg = \frac{V_1 + V_2}{2}$$

$$Vavg = \frac{Z30 ac - f + + 155 ac - f + }{43,560 f + \frac{2}{ac}}$$

(2) 
$$Q_{PH} = Q_{PIJ} \left(1 - \frac{Vavg}{S}\right)$$

$$Q_{PH} = \left(2.710 \text{ cts}\right) \left(1 - \frac{193}{590}\right)$$

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K. Reach 11

- 3. STEP 3: Prepare stage-discharge curve for Reach |
  - a. Pertinent Data
    - (1) Reach length = 5,000 feat
    - (2) Channel slope = 0.0011
    - (.3) Manning n = 0.09
    - (4) Channel shape trapezoidal
    - (5) Base width = 40 feet
  - b. See Figure 3 for stage-discharge curve
- 4. STEP #: Estimate Reach Outflow
  - a. Determine stage for  $Q_{Pli} = 1,830$  cts from Figure 3 and find volume in reach
    - (1) Stage (depth of flow) = 5.7 feet
    - (2) Volume in reach = (reach length) (cross-sectional)

 $v_1 < \frac{s}{2}$  : reach length OK

b. Determine QP(Z(TRIAL)

$$Q_{PIZ(TRIAL)} = Q_{PII} \left( 1 - \frac{V_1}{S} \right)$$

$$Q_{PIZ(TRIAL)} = \left( 1,930 \text{ cfs} \right) \left( 1 - \frac{132}{590} \right)$$

$$Q_{PIZ(TRIAL)} = 1,330 \text{ cfs}$$

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c. Compute V<sub>2</sub> using Q<sub>P(2(TRIAL)</sub>

From Figure 3 determine stage for  $Q_{P/Z(TRIAL)}$ 

Stage = 5.0 feet  
X-area = (0.5) (5.0f+)(40f+ + 405)  
= 1113 f+2  

$$V_2 = \frac{(113f+2)(5000+1)}{+3.5602+12000}$$
  
 $V_2 = 128$  acre-f+

d. Average  $V_1$  and  $V_2$  and compute  $\mathfrak{I}_{\mathfrak{D}}$ 

(1) 
$$Vavg = \frac{V_1 + V_2}{2}$$

$$Vavg = \frac{16Z acre - \hat{c} + 128 acre - \hat{c}}{Z}$$

(2) 
$$Q_{P1Z} = Q_{P11} \left(1 - \frac{Vavg}{S}\right)$$

$$Q_{P1Z} = \left(1,830 \text{ cts}\right) \left(1 - \frac{145}{590}\right)$$

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- 3. STEP 3: Prepare stage-discharge curve for Reach /2
  - a. Pertinent Data
    - (1) Reach length = 5,000 feet
    - (2) Channel slope = 0.0011
    - (3) Manning n = 0.09
    - (4) Channel shape trape zordal
    - (5) Base width ≈ 40 Lest
  - b. See Figure 3 for stage-discharge curve
- 4. STEP 4: Estimate Reach Outflow
  - a. Determine stage for  $Q_{p_{12}} = 1,380c$  from Figure 3 and find volume in reach
    - (1) Stage (depth of flow) = 5.0 feet
    - (2) Volume in reach = (reach length) (cross-sectional) area of channel)

      X-area = (0.5)(5.0f+)(40f+ + 405f+)

      = 1113f+2

$$V_1 < \frac{S}{2}$$
 : reach length OK

b. Determine Qp(XTRIAL)

$$Q_{P(2(TRIAL)} = Q_{P/2} \left( 1 - \frac{V_1}{S} \right)$$

$$Q_{PB(TRIAL)} = (1,380cfs)(1-\frac{129}{590})$$

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c. Compute V<sub>2</sub> using Q<sub>P(Z(TRIAL)</sub>

From Figure 3 determine stage for  $Q_{P_1 \mathbf{X} TRIAL}$ )

Stage = 4.6 feet  
X-area = (0.5) (4.6 feet) (40 feet + 375ff)  
= 955 f+2  

$$V_2 = \frac{(955 \text{ f+2}) (5000 \text{ f+})}{-13.560 \text{ f+2/acre}}$$

$$V_2 = 110 \text{ acre -ft}$$

d. Average  $V_1$  and  $V_2$  and compute  $Q_{P13}$ 

(1) 
$$Vavg = \frac{V_1 + V_2}{2}$$

$$Vavg = \frac{129 \ acre - ft}{2}$$

(2) 
$$Q_{P13} = Q_{P12} \left(1 - \frac{Vavg}{S}\right)$$

$$Q_{P13} = \left(1380 \text{ cts}\right) \left(1 - \frac{119}{590}\right)$$

$$Q_{P13} = 1,100 \text{ cts}$$

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PROJECT Butterfield Pand Dam COMPTO. BY BWP DATE 217/80

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M Reach 13

- 3. STEP 3: Prepare stage-discharge curve for Reach 15 ( Step 3)
  - a. Pertinent Data
    - (1) Reach length = 3,050 feet
    - (2) Channel slope = 0.0011
    - (3) Manning n = 0.09
    - (4) Channel shape trape 700 dal
    - (5) Base width = 2,080 Lest
  - b. See Figure 3 for stage-discharge curve
- 4. STEP 4: Estimate Reach Outflow
  - a. Determine stage for  $Q_{P/3} = 1,100cts$  from Figure 3 and find volume in reach
    - (1) Stage (depth of flow) = 0.7 feet
    - (2) Volume in reach = (reach length) (cross-sectional)

$$X-\text{area} = (0.5)(0.7 \text{ fest})(2.380 \text{ fr} + 2110 \text{ fr})$$

$$= 1467 \text{ fr}^2 (3050 \text{ fr})$$

$$Volume = V_1 = \frac{(1467 \text{ fr}^2)(3050 \text{ fr})}{43,560 \text{ fr}^2/\text{ang}}$$

= 103 acre-ft

 $v_1 < \frac{S}{2}$  : reach length OK

b. Determine Qp: (TRIAL)

$$Q_{P/4(TRIAL)} = Q_{P/3} \left(1 - \frac{V_1}{S}\right)$$

$$Q_{p \text{ (TRIAL)}} = (1,100 \text{ cts}) (1 - \frac{103}{550})$$

BOSTON, MASS. ROCHESTER, N.H.

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DETAIL Hydrologic Calcs

c. Compute V<sub>2</sub> using Q<sub>P M(TRIAL)</sub>

From Figure 3 determine stage for Qpl4(TRIAL)

Stage = 0.6 feet  
X-area = 
$$(0.5)(0.6f+)(2,080 + 2105f+)$$
  
=  $1256f+^2$   
 $V_2 = \frac{(1256f+^2)(3050f+)}{43,560f+^2/acc}$   
 $V_2 = 88 acce-ff$ 

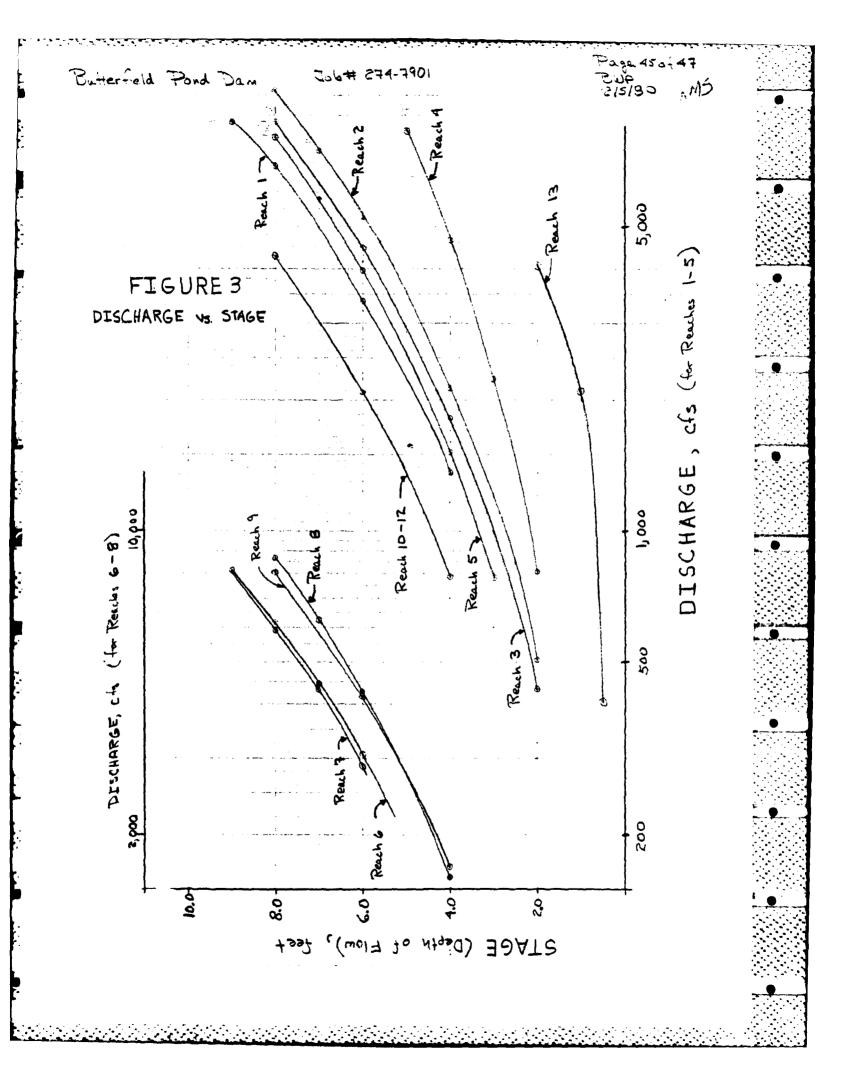
d. Average  $V_1$  and  $V_2$  and compute  $Q_{P14}$ 

(1) 
$$Vavg = \frac{V_1 + V_2}{2}$$

$$Vavg = \frac{103ac - f + 98ac - f}{Z}$$

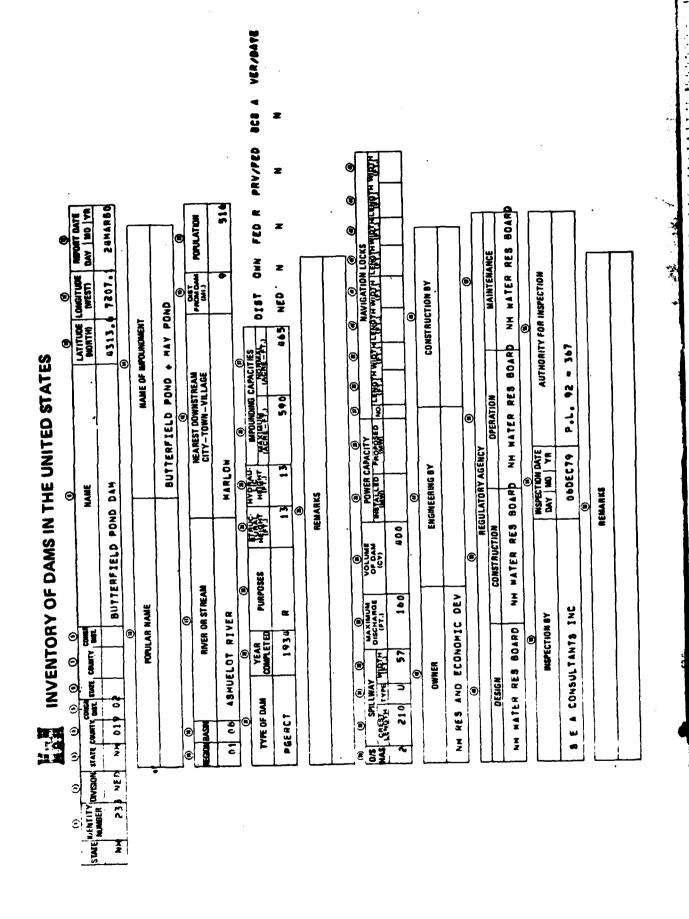
(2) 
$$Q_{P14} = Q_{P13} \left(1 - \frac{Vavg}{S}\right)$$

$$Q_{P14} = \left(1,100 \text{ cts}\right) \left(1 - \frac{95}{590}\right)$$



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3. 341-10 DIETZBEN GRAPH P.



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